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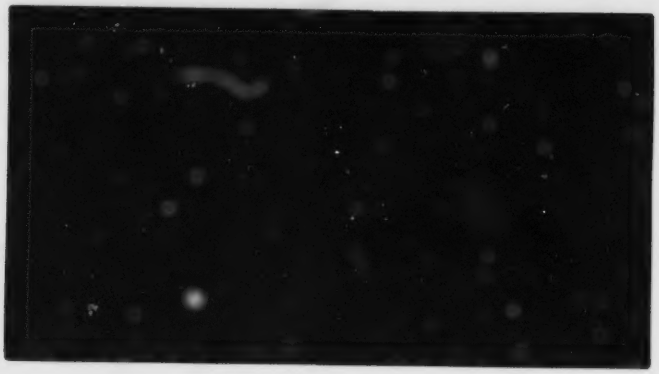

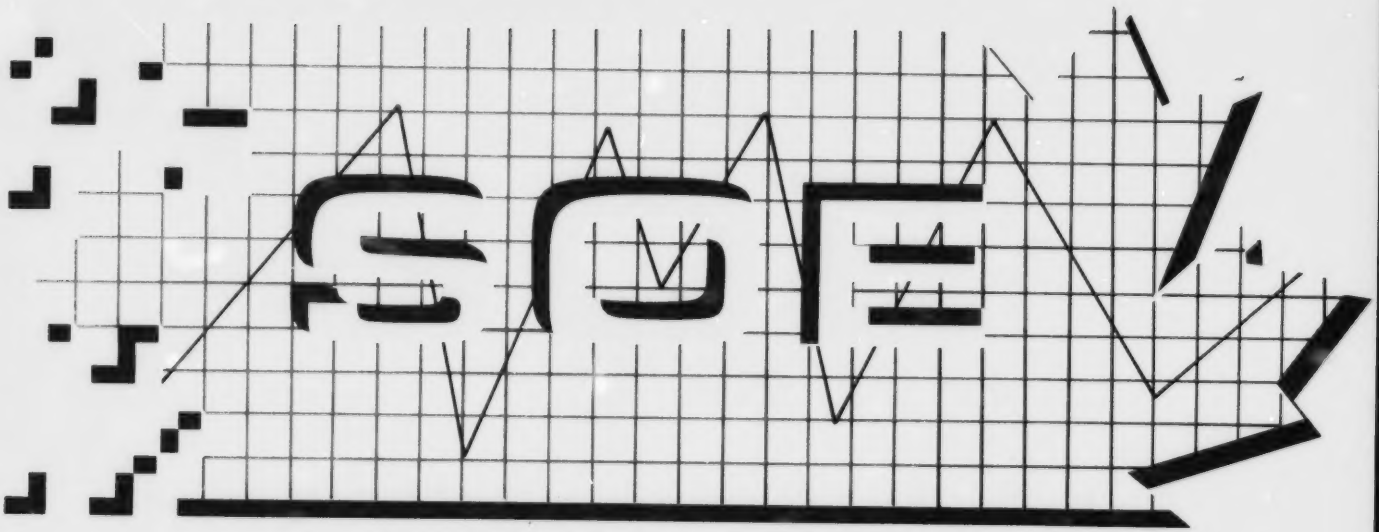

Strategies and Scientific Methods Division
State of the Environment Reporting Branch
Canadian Wildlife Service

Canada

THE USE OF INDICATORS TO SHOW THE STATE AND RECENT TRENDS IN SUSTAINABLE DEVELOPMENT: A FORESTRY PILOT STUDY

Report No. 11

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TABLE OF CONTENTS

		Page
1.	INTRODUCTION	1
2.	APPROACH	2
3.	SUSTAINABILITY TRENDS	6
	3.1 Forest Harvesting and Renewal	6
	3.2 Efficiency of Resource Use	20
	3.3 Environmental Effects of Forestry	28
	3.4 Genetic Conservation	47
4.	CONCLUSIONS	51
	4.1 Information Gaps	52
	4.2 Avenues for Further Study	53
REFERENCES		56
APPENDIX I:	SUSTAINABLE DEVELOPMENT INDICATORS FOR FORESTRY	
APPENDIX II:	GLOSSARY	
APPENDIX III:	CANADIAN FORESTRY SERVICE DATA ON DOMESTIC CONSUMPTION OF FOREST PRODUCTS 1960-2000	

1. INTRODUCTION

A recent study by the author, titled The Use of Indicators to Show the State and Recent Trends in Sustainable Development in Canada, presented a framework for measuring changes and trends in socio-economic activities as indicators of a move toward sustainable development. This report presents results of a forestry pilot study which was conducted to implement the concept set forth in the earlier study.

The sustainable development indicators concept was investigated as part of Environment Canada's State of the Environment (SOE) Reporting Program. The program was established to provide information on the status and trends of environmental quality and natural resource use. A major objective is to encourage sustainable use of natural resources. Thus it is appropriate for the SOE program to identify particular measures or indicators of sustainability and to apply these indicators in a study of economic development in the forestry sector. The rationale for this approach is the acknowledged need to adapt socio-economic activities to the natural limitations that govern life on earth.

2. APPROACH

This study evaluates Canadian forestry against a standard of sustainability derived from the concept of sustainable development set forth by the World Commission on Environment and Development (1987). Sustainable development is defined here as: the utilization of resources and the environment to optimize economic and other societal benefits today while not damaging prospects for their use by future generations.

To achieve sustainability, development must meet four basic goals:

1. protecting natural systems that support life on earth (atmosphere, water, soils, living organisms);

2. preserving genetic diversity;

3. using renewable resources at a sustainable rate; and

4. foreclosing as few future options as possible in using non-renewable resources.

To use forestry as a model for applying the sustainable development indicators in a state of the environment report

format, it is necessary to define sustainable forestry. In this case, forestry is viewed in a broad sense, to include forest products processing as well as resource extraction. Activities involved in forest management for purposes other than commercial forestry (such as parks, reserves and wildlife habitat) are also included.

Thus sustainable forestry is defined as forestry which adheres to the following objectives:

1. Harvest at levels which allow resources to be replenished without adverse environmental effects or any reduction in productivity of the resource.

2. Take into account effects on other components of the biosphere: prevent degradation of the atmosphere, water and land by pollution or physical disturbance; and protect the cycles that replenish natural systems (flows of energy and matter over time and space).

3. Renew resources (by replanting, encouraging regeneration).

4. Ensure efficient resource use.

5. Optimize allocation of resources among conflicting interests.

6. Maintain representative ecosystems.

7. Prevent extinction of individual species and sub-species.

8. Prevent loss of genetic diversity within species.

9. Control the rate of depletion of non-renewable resources (minimize waste, optimize allocation).

10. Develop environmentally benign substitutes for scarce resources and for those which have adverse effects on the environment.

11. Use non-renewable resources economically and efficiently.

To guage progress toward these goals and objectives, this study applied a variety of specific measures using national level data. The aim was to use indicators for which national data for the last twenty years are available. However, in a number of cases, an incomplete data base had to be relied upon. The earlier report by the author, The use of Indicators to show the State and Recent Trends in

Sustainable Development in Canada, includes 19 indicators which have been used as the basis of the current report. These are listed in Appendix I.

To clarify the concept of indicators of sustainable economic development, the following definition is offered for a "sustainable development indicator":

A single quantity which reflects conditions in socio-economic activity in relation to the goal of sustainable development.

Thus, using the definition for sustainable development given on page 2, a sustainable development indicator is a measure of socio-economic activity which can be used to determine progress over time in ensuring that a particular activity is carried out in a manner which will optimize economic and other societal benefits today while not damaging prospects for future generations.

3. SUSTAINABILITY TRENDS

This section presents the condition and trend data for each of the forestry indicators, individually and grouped for the various objectives for sustainable development described in the earlier report on sustainable development indicators.

3.1 Forest Harvesting and Renewal

The state of the forest resource is a function of two opposing forces: withdrawals of biomass and nutrients, and replenishment of each of these. When withdrawals exceed replenishment, our forest stocks are declining. When replenishment exceeds withdrawals, the stocks are increasing. Withdrawals result primarily from logging, fire, insects and disease. Replenishment is a function of 1) natural increases due to reproduction and growth of trees and transfer of nutrients, plus 2) human intervention to enhance reproduction and growth--through planting and seeding of trees; fertilization; fire, insect and disease control; and silvicultural practices* such as site preparation, spacing, thinning and pruning.

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*For definitions of technical terms used in this report, see Appendix II.

In simple terms, trends in forest stocks can be described by the formula:

Present stocks	-	Withdrawals	+	Replenishment	=	Future stocks

In fact the dynamics of these withdrawals and replenishment are extremely complex, and the information base with which to measure them is far from complete. Those factors which can be measured, with varying degrees of accuracy, include:

Withdrawals

1) area of forest harvesting;
2) volume of timber harvested;
3) area of forest affected by pests;
4) volume of timber destroyed (or made commercially useless) by pests;
5) area of forest affected by fire; and
6) volume of timber consumed by fire.

Replenishment

1) annual growth of forest trees (volume of wood added per year to a given area);

2) area receiving reforestation treatments (site preparation, direct seeding or planting);

3) effectiveness of reforestation treatments (survival and growth rates of young forests following logging); and

4) area receiving silviculture treatments.

Increases in any of the identified replenishment factors serve to reduce pressure on the resource stocks, while increases in any of the withdrawal factors intensify pressure on the resource.

There are several measures which can be made of overall resource stocks to determine the withdrawal/replenishment balance:

1) area and wood volume estimates for forests;

2) the ratio of the area of forest harvesting to the area of reforestation treatments (area planted + area direct seeded + area of site preparation);

3) stocking level of productive forest land--an important concept here is the backlog of non-reforested, inherently productive land, classified by foresters as not satisfactorily restocked (NSR);

4) wood supply figures--the production/extraction balance as reflected by allowable cut* calculations and actual timber volumes extracted.

To understand the dynamics of withdrawal and replenishment in forestry, it is important to realize that, from the standpoint of commercial forestry, resource stocks can be seen as having two basic components: 1) the growing stock--trees, and 2) the forest land base. To a certain extent, these two resources can be seen as independent: the volume of wood in the forest can increase, at least in the short term, while the area of forest land decreases, and vice-versa.

The following sections illustrate how the available data for these factors can be interpreted to evaluate the sustainability of use of Canadian forests. It is important to keep in mind the limitations of nationally aggregated forestry statistics. Most forestry data are collected at the operating level--for individual forest management units within a province. These data are then aggregated to the regional, provincial and national levels to produce the Canada-wide tabulations referenced here. There is information loss at each stage as data are aggregated and

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*See page

concept and the limitations of calculated values.

standardized. Thus the discussion which follows should be considered as a broad overview supported by statistics which illustrate general conditions and trends.

3.1.1 Withdrawals

Table 1 shows that the area of forest harvesting in Canada rose from 682,572 ha. in 1975 to 901,552 ha. in 1985, an increase of 32% over the ten-year period. Table 2 shows that, over the same decade, the volume of wood raw material (roundwood--raw material "in the round") resulting from this harvest rose from 115,262,000 m^3 to 168,654,000 m^3, an increase of 46%.

Table 3 shows the additional estimated volume depletion due to insects and diseases. These two factors consumed approximately 107,400,000 m^3 per year for the period 1977 to 1981, an amount equivalent to 71% of the commercial harvest (Economics Branch, 1988).

Honer and Bickerstaff (1985) estimate the total area of stocked, productive, nonreserved forest land "harvested" by logging, pests (insects and diseases) and fires at 2,215,040 ha. annually for the period 1977-81. Of this, approximately 34% was due to logging, 43% due to fire, and 23% was consumed by pests.

Table 1

Area of Forest Harvesting in Canada (1975-1985)

Year	Clearcuting ha. (% of total)	Other ha. (% of total)	Total ha.
1975	572,016 (84)	110,556 (16)	682,572
1976	583,846 (84)	112,692 (16)	696,538 703,711*
1977	606,498 (83)	126,722 (17)	733,220 735,189*
1978	694,633 (85)	122,185 (15)	816,818 823,009*
1979	749,537 (86)	122,191 (14)	871,728 876,433*
1980	781,626 (88)	103,089 (12)	884,715 881,419*
1981	708,643 (88)	94,987 (12)	803,620 802,637*
1982	679,631 (89)	86,916 (11)	766,547 762,935*
1983	739,351* (89)	89,414* (11)	829,956*
1984	798,823* (89)	97,610* (11)	898,069*
1985	813,409* (90)	87,018* (10)	901,552*

*Updated figures from Kuhnke (1989). Other figures are from Kuhnke and Brace (1986). Kuhnke (1989) does not provide a breakdown of harvesting methods for the Yukon or Northwest Territories, although the total area of harvesting for the territories is included in the Canadian totals.

Table 2

Volume of Timber Obtained from Canadian Forests: Roundwood Production (1950-1985)

Year	1,000 m^3		
	Industrial roundwood	Fuelwood	Total
1950	74,106	11,509	85,615
1960	86,505	6,751	93,256
1970	117,324	4,096	121,419
1971	117,991	3,734	119,701
1972	120,748	3,383	124,131
1973	140,343	3,462	143,806
1974	134,416	3,512	137,928
1975	111,497	3,765	115,262
1976	135,227	3,899	139,126
1977	141,580	3,682	145,262
1978	150,918	4,183	155,102
1979	156,464	4,506	160,970
1980	150,649	4,731	155,380
1981	139,084	5,488	144,572
1982	121,343	5,673	127,016
1983	150,724	6,197	156,921
1984	160,867	6,635	167,502
1985	161,985	6,669	168,654

From Economics Branch (1988).

Table 3

Estimated Average Annual Depletion

Caused by Important Pests (1977-1981)

Pest type	1,000,000 m^3			
	Average Annual Mortality Volume	Growth Reduction	Wood Destruction	Total
Insects	44.0	18.5	--	62.5
Diseases	16.1	3.8	25.0	44.9
Total	60.1	22.3	25.0	107.4

From Economics Branch (1988)

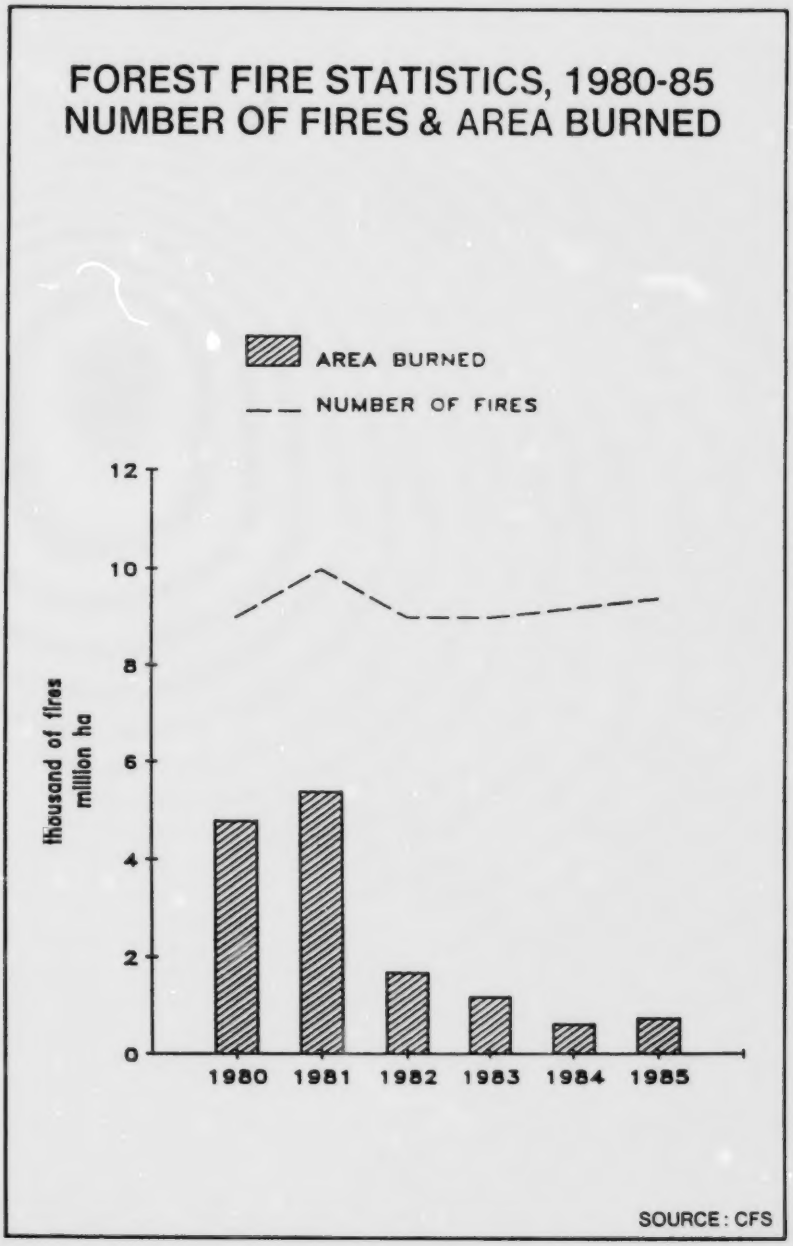
Figures on fire and pest losses should be viewed as approximations. For the 1976 national forest inventory, Bowen (1978) states that data are not available for area or volume depletion by insects, diseases and other causes. It is also important to keep in mind that annual depletion due to these causes is extremely variable, and a portion of the timber on areas affected by fire and insects is normally salvaged for commercial use. Honer and Bickerstaff (1985) emphasize that not all fires result in significant volume losses. Thus while the annual "harvest" by fire appears to be quite large, burned areas are not a total loss to commercial forestry.

Although the area burned varies year to year, fire control efforts are generally viewed to be increasing in efficiency. This observation is supported by Figure 1, which shows fire losses for 1980 to 1985. Although the number of fires reported was relatively constant, the total area burned declined steadily.

3.1.2 Replenishment

Honer and Bickerstaff (1985) provide a good summary of the sources and amounts of wood volume growth in Canadaian

Figure 1



From Canadian Forest Industries Council (1987).

forests, based on data for 1977-81:

> Canada's forests annually increase by about 338 million m^3 of merchantable volume. The standing forest contributes 335 million m^3 and natural regeneration is responsible for an additional 3 million m^3. At present, about 130,000 m^3 of growth is attributable to silvicultural practicessuch as planting, spacing, fertilization and stand tending. These accruals to merchantable volume are 78% in softwoods and 22% in hardwood tree species.
>
> The growing stock capital of forest land and the standing timber on it contributes 99% of the annual volume growth. Canada's current growing stock is predominantly the natural forest. It receives extensive forest management essentially in the form of fire protection but the rates of growth are low, averaging about 1.7 m^3/ha/year.

Table 4 shows the land area of Canada which was treated for reforestation from 1975 to 1985. The total area receiving treatments of some type (planting, seeding or site preparation) rose from 320,509 ha. in 1975 to 588,183 in 1985, an increase of 84%.

Kuhnke (1989) provides a measure of the effectiveness of this reforestation effort. He estimates that 50.1% of the area harvested becomes satisfactorily stocked through natural regeneration. Of the area with direct seeding, 59.2% is expected to become satisfactorily restocked. And 70.1% of the area planted with spruce or pine (the primary commercial softwood species) is expected to become satisfactorily stocked without retreatment (see Figure 2).

Table 4

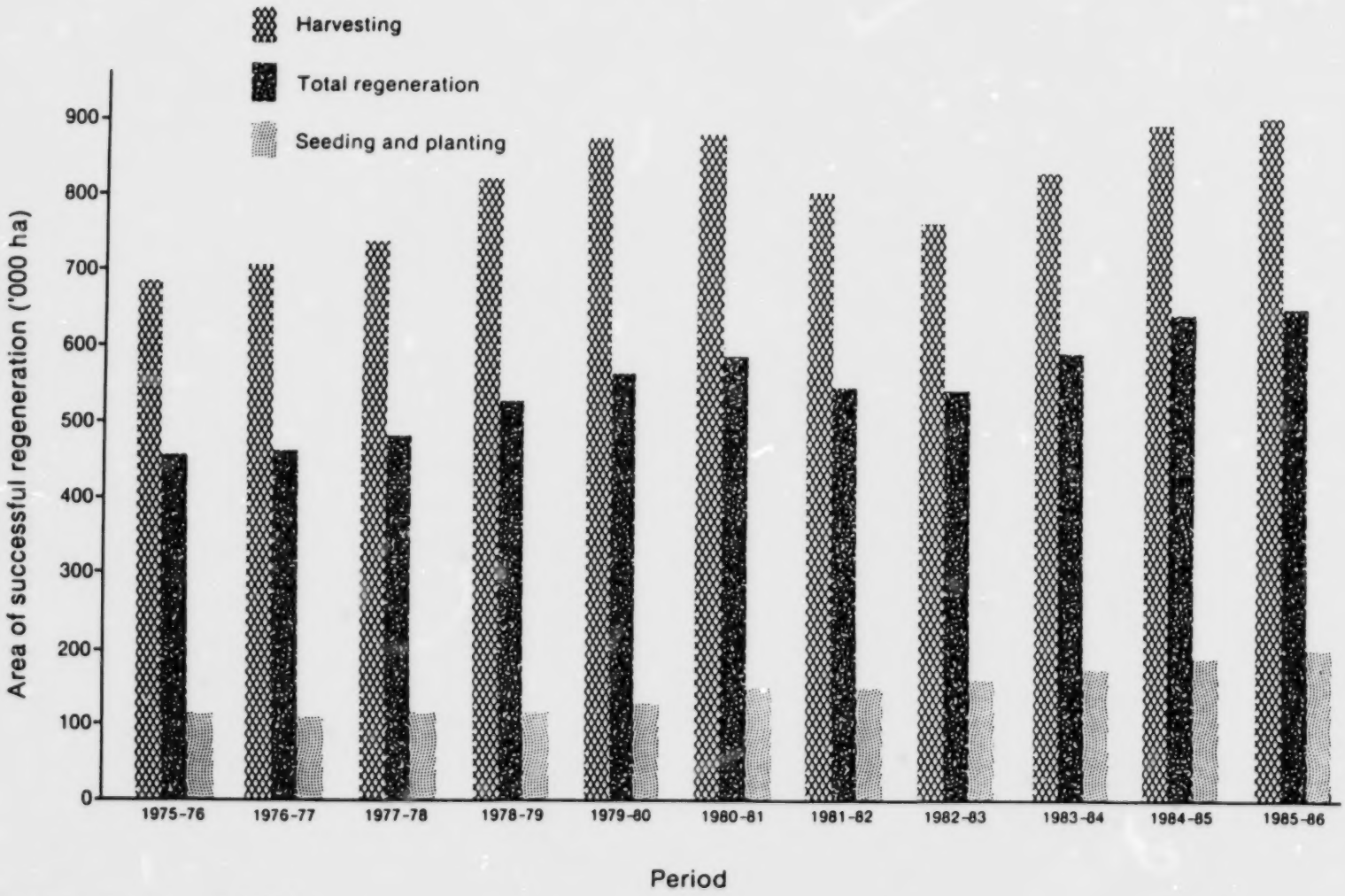
Area of Reforestation Treatments in Canada (1975-1985)

Year	Area of site preparation	Area of direct seeding	Area planted	Total area receiving reforestation treatments	Area harvested	Area receiving reforestation treatments as a percentage of area harvested
	ha.					
1975	158,163	34,298	128,048	320,509	682,572	47
1976	152,391	35,933	120,397	308,721	703,711	44
1977	144,184	42,729	121,667	308,580	735,189	42
1978	159,409	37,043	128,047	324,499	823,009	39
1979	184,821	39,389	143,038	367,248	876,433	42
1980	194,305	65,007	151,960	411,272	881,419	47
1981	192,400	42,593	169,632	404,625	802,637	50
1982	208,172	50,279	185,445	443,896	762,935	58
1983	224,189	37,348	215,695	477,232	829,956	58
1984	253,099	33,743	239,953	526,795	898,069	59
1985	300,974	26,189	261,020	588,183	901,522	65

From Kuhnke (1989).

Figure 2

Area of Successful Regeneration Relative to Area Harvested for Canada
1975-76 to 1985-86 (Based on 1983-84 to 1985-86 National Average Success Rates)

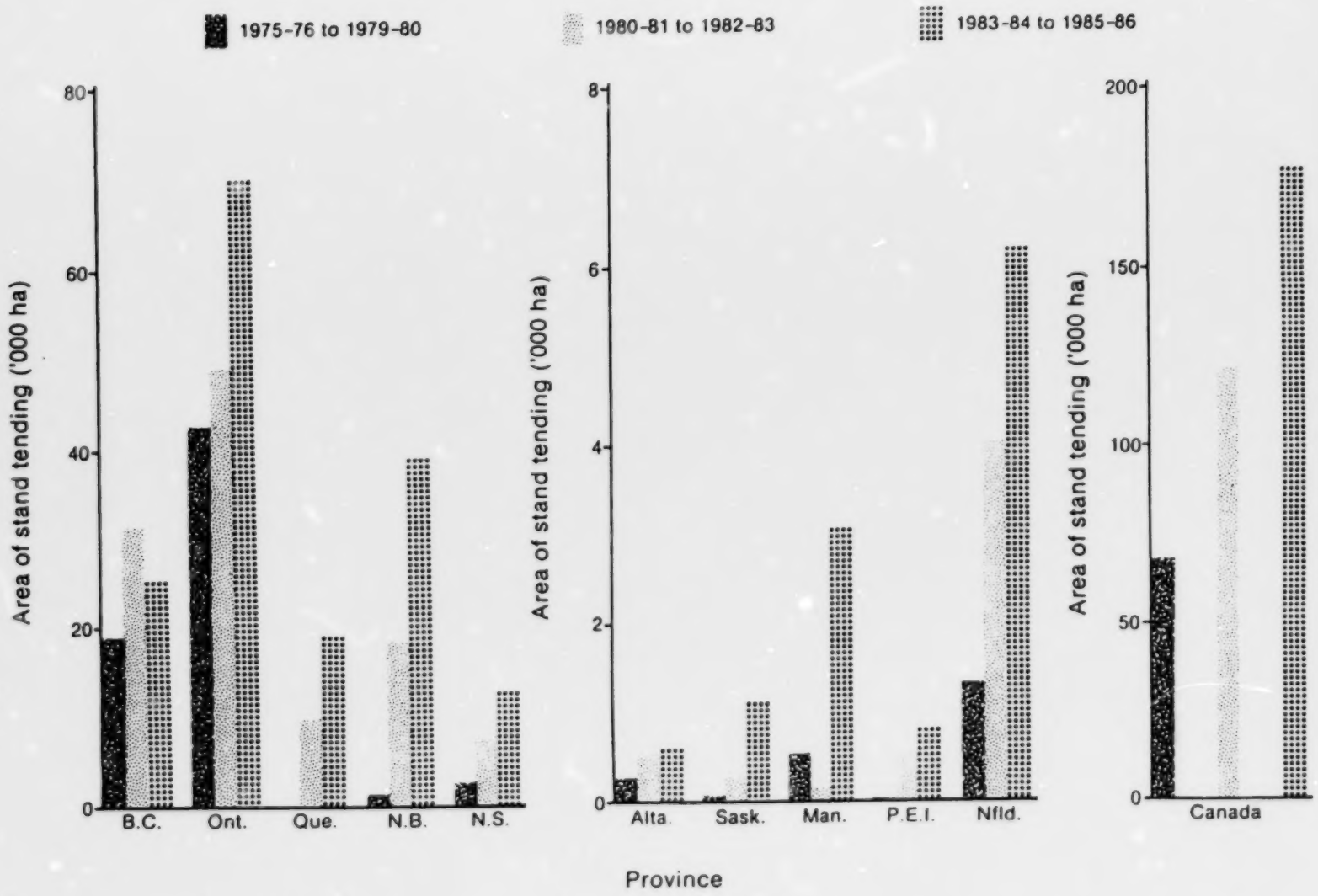


From Kuhnke (1989).

Kuhnke (1989) reports that the area of stand tending rose from 37,382 ha. in 1975 to 216,592 in 1985, an increase of 479% (see Figure 3). Although it is difficult to translate these figures into estimates of future forest growth, the substantial increase in silvicultural activity should have a positive effect on Canada's wood supply.

Figure 3

Average Area of All Methods of Stand Tending, by Period



From Kuhnke (1989).

3.1.3 The Condition of Forest Resource Stocks: The Withdrawal/Replenishment Balance

Table 5 provides a breakdown of the area, species, age-class and volume distribution of Canadian commercial forests based on Canadian Forestry Service 1981 and 1986 FORSTATS national inventory information. The two inventories should not be compared directly because there were changes in the area of coverage and the survey techniques between the two inventory periods. However, the data do appear to indicate a decrease in the amount of timber in the lower age classes, with an increase in the higher age classes. This implies an increase in the wood volume currently available to harvest, but a possible long-term wood supply problem due to the limited area of young forest to replace what can now be logged.

When studying the inventory data, it is advisable to keep in mind the words of F.L.C. Reed & Associates (1978):

> Knowledge of the forest resource base is quite inadequate. The inventories in use vary so much that is almost impossible to aggregate them. They are frequently 10-20 years out of date. As a rule they provide far too little information for effective planning of forest management and other essential activities. Coverage of smaller privately owned forests is generally minimal.

While this certainly still holds true to an extent, Lowe (1989) says that the forestry data base is steadily improving.

Table 5

Gross Merchantable Wood on Inventoried, Stocked, Productive, Nonreserved Forest Land in Canada

Class	1981 Inventory	1986 Inventory
A. Maturity class (1,000,000 ha.)		
Regeneration	16.0	11.5
Immature	85.7	77.8
Mature	68.9	83.3
Overmature	6.3	13.1
Uneven-aged	0.5	0.4
Unclassified	14.0	22.0
Total	191.4	208.2
B. Maturity class ($1,000,000\ m^3$)		
Regeneration	180	140
Immature	6,738	5,625
Mature	11,030	13,619
Overmature	777	2,117
Uneven-aged	23	34
Unclassified	896	1,618
Total	19,644	23,154
C. Species group ($1,000,000\ m^3$)		
Softwoods	15,570	17,834
Hardwoods	4,074	5,320
Total	19,644	23,154

From Bonnor (1982) and Economics Branch (1987 and 1988).

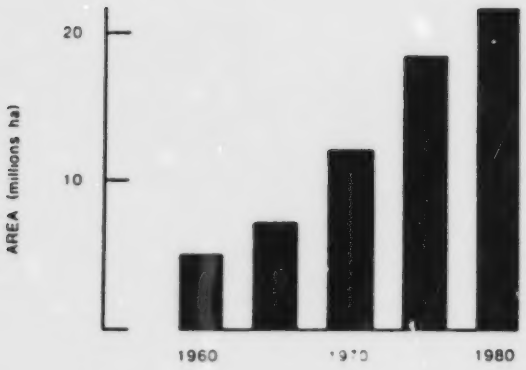
An important and controversial aspect of the forest resource base is the unreforested backlog of inherently productive forest land which is not presently supporting commercially desirable forests. These areas, termed not satisfactorily restocked (NSR) lands are increasing in size every year.

The NSR lands are an important concern because they represent a significant threat to Canada's forest resource base. The concept is controversial because of doubts about the accuracy of reported figures, disagreement among foresters about the seriousness of the problem, and the subjective interpretation of what represents "satisfactory" stocking. What one forester or agency considers unsatisfactory stocking may be acceptable to another.

F.L.C. Reed & Associates (1978) report that in 1977, NSR lands covered nearly 30 million ha., and the area was growing by 200,000 ha. annually. Canada's Auditor General reported the same rate of increase in NSR as part of his 1988 analysis of the Canadian Forestry Service (Auditor General of Canada, 1988). NSR data provided by Honer and Bickerstaff show a constant rate of increase since 1960 (see Figure 4). They provide a breakdown of the contribution to NSR by logging, fire, pests and "other", although for 52% of the area reported, the cause is "undetermined" (see Table 6).

Figure 4

Cumulative Area of Productive Forest Land that is Not Satisfactorily Restocked to Commercial Tree Species



From Honer and Bickerstaff (1985)

Table 6

NSR Forest Land Areas by Disturbance and Years

(Productive, Nonreserved Forest Land)

	PERIODS AND AREAS[1]						
	1,000,000 ha						
Disturbance	Up to 1960	1961-1965	1966-1970	1971-1975	1976-1980	Total	Percent of National Total
Cutover	..	0.001	0.272	.[illegible]	0.454	1.802	8
Burn	0.006	0.032	2.001	2.[illegible]71	0.808	5.017	23
Pest	..	..		.092	0.013	0.025	..
Other	..	0.471	1.223	.566	0.409	3.669	17
Undetermined	5.225	1.453	1.488	1.631	1.604	11.401	52
Canada[2]	5.231	1.956	4.984	6.456	3.287	21.914	100
Five-year Average		0.391	0.997	1.291	0.657		

NOTES:

1. Bonnor 1982 and Provincial Forestry Agencies.
2. Totals may not add due to rounding.

From Honer and Bickerstaff (1985)

Bonnor (1982) describes some significant limitations of the NSR data from the 1981 national inventory: for one quarter of the area reported, data were more than 20 years old, and only one percent of the NSR lands had been classified both by cause of disturbance and site quality.

Lowe (1989) says that stocking figures are not uniformly reported for all parts of Canada, and there have been errors in classifying stocking based on air photo interpretation. He says that the FORSTATS program no longer uses the term NSR, but instead uses a more general category of "unproven stocking" to indicate areas which are not known to be fully reforested. The unproven stocking information for the 1986 inventory is not yet available for much of the country.

To evaluate Canada's wood supply, it is important to distinguish between the physical supply and the and the economically accessible supply. Inventory figures (including the ones provided in this report) are normally reported for the former, while the latter category is a function of "tree size, quality, species mix, logging costs and infra-structures providing transportation, processing, and forest maintenance facilities" (Honer and Bickerstaff, 1985). The area of timber which is economically accessible therefore varies with the market for forest products. Reporting on the 1976 national inventory, Bowen (1978)

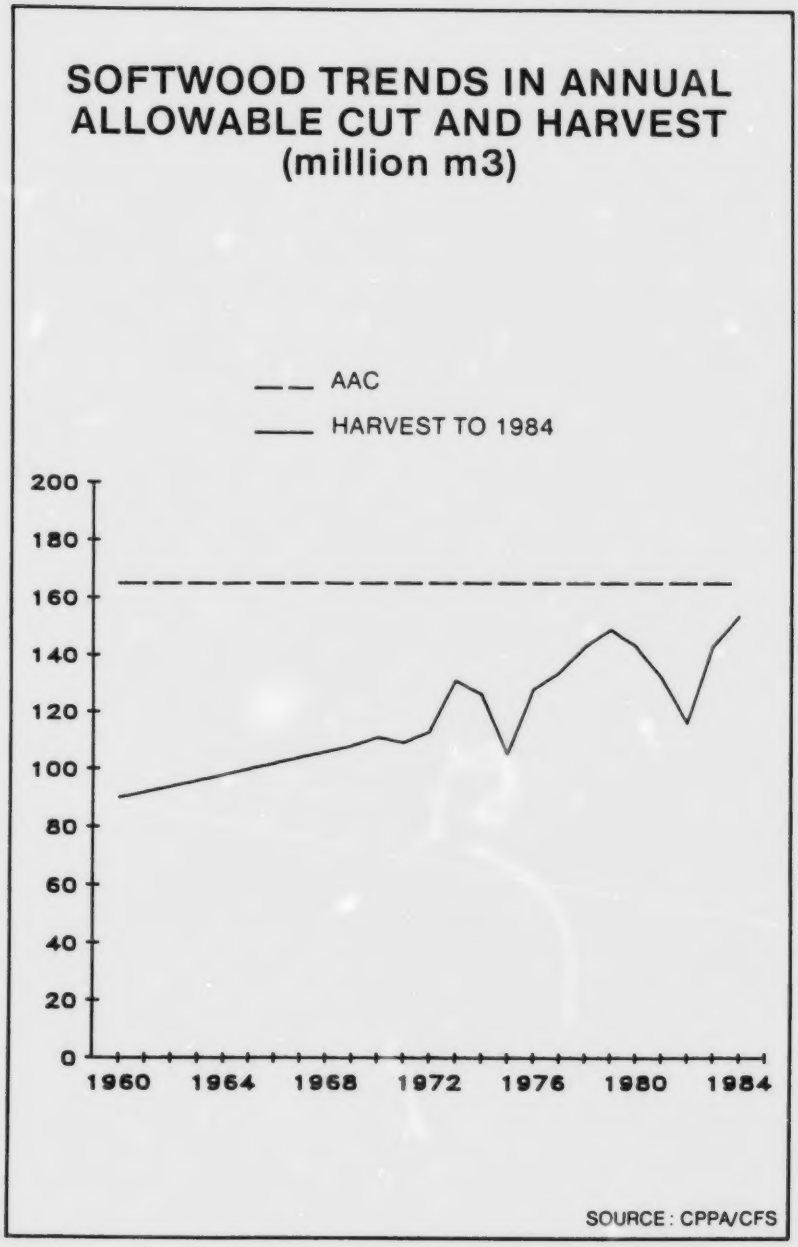
states that the inventoried, production (available for commercial forestry), productive forest consisted of 1,984,000 km^2, of which 1,611,000 km^2 (81%) was economically accessible.

To obtain an overall measure of the wood supply, it is necessary to relate the calculated allowable cut (the wood considered by forest managers to be available for harvest over a particular period in a particular area) to the actual harvest. Figure 5 shows the relationship between the harvest and the annual allowable cut from 1960 to 1984. The graph indicates an unused, but steadily shrinking reserve of uncut wood for each year. However, F.L.C. Reed & Associates (1978) question the validity of Canadian allowable cut figures:

> Allowable cuts in use by the provinces are...so diverse that it is natural to question whether they can all be valid. They tend to give a false sense of confidence, in spite of the subjective judgements they contain. It is doubtful if any of them take into account the true dynamics of the forest with respect to stand development, interspecies competition and especially hardwood encroachment [on commercially desirable softwood stands].

In spite of their reservations about the available data, F.L.C. Reed & Associates (1978) discuss the economically accessible forest in relation to the allowable cut and identified trends in the harvest and consumption of timber. An annual allowable cut of about 256 million m^3

Figure 5



From Canadian Forest Industries Council (1987).

and an average harvest of 156 million m^3 left an economically accessible reserve of approximately 57 million m^3. This reserve, comprising 22% of the allowable cut, was the amount estimated to be available for expansion of the forest industry in the late 1970's. However, such a reserve must be viewed in relation to the growth in the area of NSR land since the calculations were made. On the other hand, the recent increases in silviculture inputs should have a positive influence on wood supply.

Another important factor in our future wood supply is the effect of air pollution on forests. Fraser et al. (1985) cite the serious lack of information on the effects of long range transport of air pollutants on forest growth. In the absence of the desired information base, they conducted a survey of experts for their opinions on the likelihood and extent of a reduction in forest productivity over the three decades prior to the survey, with projections for the next three decades. The survey results suggest that forest productivity may have declined by 5% in Atlantic Canada and 7% in Ontario and Quebec in the past 30 years. They provide 30-year projections based on three pollution scenarios:

1) with increased pollution levels--forest productivity declines of 8 to 11% in Eastern Canada;

2) with constant pollution levels--high likelihood of a decrease in productivity; and

3) with declining pollution--no change in productivity.

Honer and Bickerstaff (1985) sum up the supply situation by responding to three important questions:

> Is Canada running out of wood? Current statistics indicate that a surplus of old growth timber is available for harvest, however, these data tend to mask the local and regional shortages that do exist.
>
> Are we planting enough trees? About 20% of the lands that are depleted annually due to harvest, fire and pests go out of production even though efforts in forest renewal have increased markedly. Silvicultural activities must be expanded if we are to maintain the 1981 land base for forestry.
>
> Are we cutting too many? The data suggest that harvesting levels can increase to take advantage of forecasted demands for forest products, however all cutover lands must be restocked immediately to ensure continued economic prosperity from our forests.

Thus the authors maintain that the large wood volumes contained in our existing old growth forests provide the opportunity for a short term increase in the harvest (liquidating the old trees before they are destroyed by insects and disease). But they warn that the growth in NSR must be reversed to ensure that the forests which replace our existing ones will provide a supply of timber adequate to meet society's demand for forest products.

3.2 Efficiency of Resource Use

The efficiency of use of natural resources is a function of the relationship between two basic factors: 1) raw material inputs, and 2) outputs (products, by-products and wastes). in simple terms, efficiency of resource use increases as:

- the ratio of inputs/products decreases; and
- the ratio of products/wastes increases.

Thus efforts to conserve resource inputs and reduce or recycle wastes indicate a trend toward sustainable resource development.

In the use of forest resources, inputs range from the silvicultural measures involved in managing forests to increase tree growth to manufacturing and transportation of finished products. These inputs include land, labor, energy, fuel, wood and fibre. Products include pulp, paper, lumber, firewood, wood chips and various manufactured goods. Wastes include wood waste, anywhere along the line from the forest to the consumer, chemical pollution from mills, and unused or underused forest products.

Many of these inputs and outputs are difficult to quantify, and the data base to support those measurements which can be made is incomplete. However, a number of different measures can be applied to the available data. These include:

Inputs

1) area of silviculture treatments (harvest, regeneration and stand tending);

2) area of pest control;

3) amount of wood and fibre raw material (roundwood) supplied to the industry; and

4) energy consumed by pulp and paper mills.

Products

1) wood, fiber and manufactured products.

There are some discrete measures which can be applied to the available data to reflect the input/output balance of

the forest industry:

1) the ratio of wood consumption by industry to industrial production;

2) the area of forest pest control in relation to the area of pest damage;

3) the ratio of energy inputs to product outputs for pulp and paper mills; and

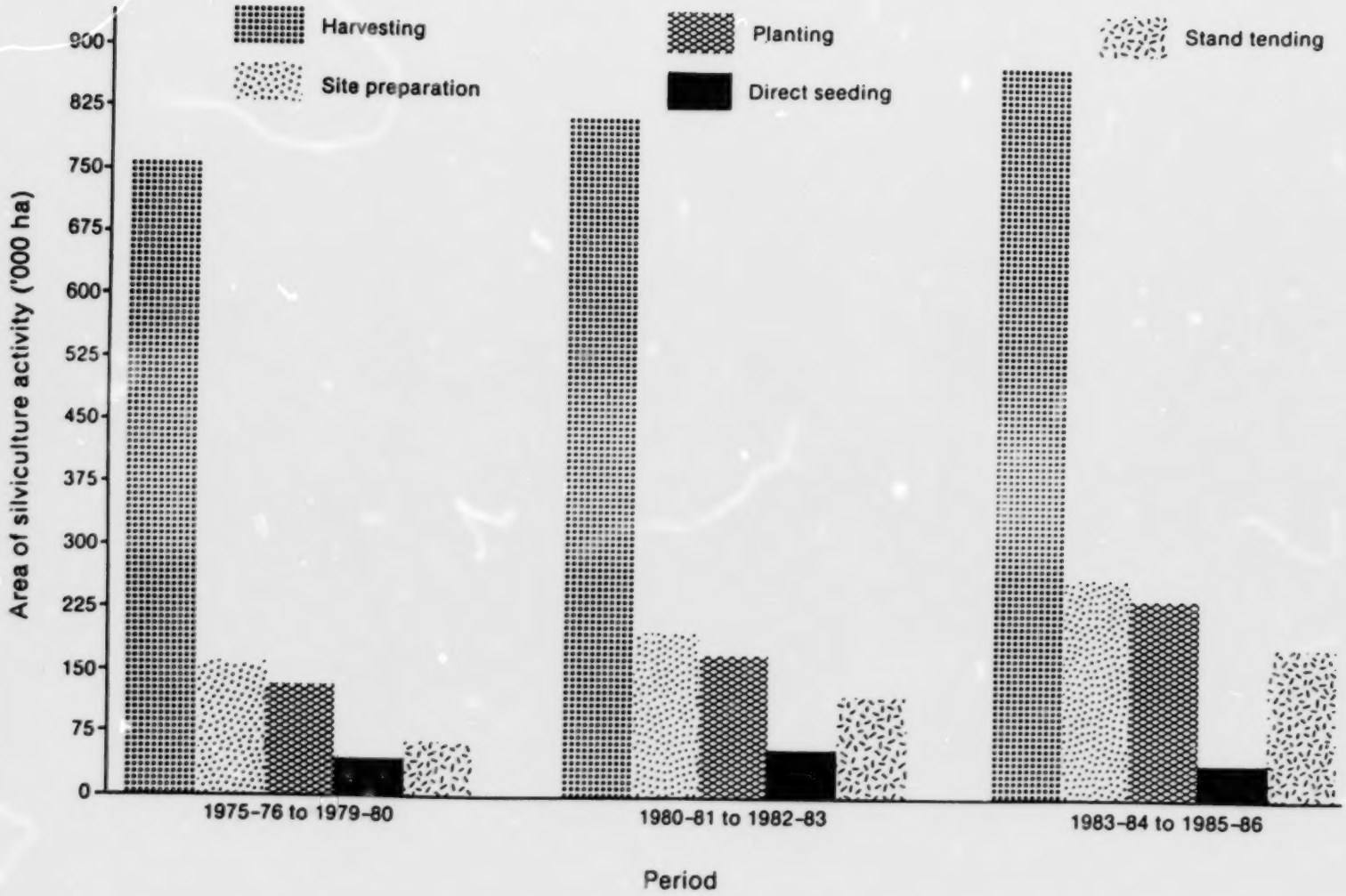
4) trends in the flexibility and degree of utilization of wood and fiber in pulp and paper mills (including rates of usage of recycled wastes as raw material for mills).

The following sections show how the available data can be interpreted to identify trends in efficiency, and thus sustainability, of forest resource use.

3.2.1 Inputs

Figure 6 shows the amount of silviculture in Canada from 1975 to 1985. There was an increase in all forms of treatments except direct seeding (note that harvesting is considered a silvicultural activity, because logging can promote tree growth by opening up the forest to sunlight

Figure 6. Average Area of Silviculture Activity for Canada, by Period



From Kuhnke (1989).

and providing ground surface conditions conducive to seed germination).

Table 7 shows a significant decline in pest control inputs for Canadian forestry. The area of pest control decreased from 5,510,952 ha. in 1975-76 to 1,452,735 ha. in 1985-86.

Table 2 shows that the amount of wood provided to the industry increased from 74,106 m^3 in 1950 to 161,985 m^3 in 1985, a 119% increase over the 35 year period.

As Table 8 illustrates, the pulp and paper industry is very energy intensive. The average annual energy cost per establishment is $8.61 million compared with $158,000 for all manufacturing plants. Energy accounts for 24% of the total cost of materials in pulp and paper, as opposed to an average 5% for all manufacturing. These figures show the major potential benefits from energy conservation measures in the forest products industry.

3.2.2 Products

Roberts and Luck (1985) document the Canadian domestic consumption of forest products from 1960 to 1980, with projections to the year 2000. The 1960 to 1980 annual compound rate of growth in consumption ranges from 1.3% for

Table 7

Area of Pest Control in Canada (1975-76 to 1985-86)

Province or territory	Area of pest control (ha)											
	1975–76	1976–77	1977–78	1978–79	1979–80	1980–81	1981–82	1982–83	1983–84	1984–85	1985–86	Total
British Columbia[a]	1 785	2 667	2 384	2 908	2 287	1 564	3 830	0	2 374	3 948	3 488	27 235
Alberta	0	0	0	0	0	0	0	0	0	0	0	0[b]
Saskatchewan	0	0	0	0	0	0	0	0	12	434	0	446
Manitoba	0	0	0	0	0	0	0	0	0	428	760	1 188
Ontario	14 167	41 060	10 522	4 085	22 072	36 422[c]	2 477	28 685	43 770	47 280	10 339	280 879
Quebec	(2 800 000)[d]	(2 900 000)	(1 400 000)	(1 200 000)	(600 000)	188 511	705 164	1 298 495	1 253 605	712 282	698 343	13 756 400
New Brunswick	2 695 000	3 881 000	1 682 000	1 554 000	1 598 000	1 900 000	1 693 000	1 867 570	1 245 000	32 000	545 000	19 392 570
Nova Scotia	0	0	556	25 670	30 752	25 670	31 195	19 153	20 726	20 537	49 719	223 978
Prince Edward Island	0	0	0	0	0	0	0	0	0	0	0	0
Newfoundland	0	0	76 910	376 600	0	0	0	0	0	0	145 086	598 596
Yukon Territory	0	0	0	0	0	0	0	0	0	0	0	0
Northwest Territories	0	0	0	0	0	0	0	0	0	0	0	0
Canada	5 510 952	6 824 727	3 172 372	3 163 263	2 253 111	2 152 167	2 455 666	3 213 903	2 565 487	1 516 909	1 452 735	34 281 292

[a] Mainly dwarf mistletoe control, sanitation treatments, and spraying against western spruce budworm that began in 1983–84 using *Bacillus thuringiensis*
[b] Does not include the control program started in 1979 against the mountain pine beetle that was conducted over an area of 32 000 ha
[c] All figures from 1980–81 to 1985–86 include insecticides and herbicides. Figures in Kuhnke and Brace (1986) for 1981–82 and 1982–83 were areas of aerial insecticide spraying only
[d] Numbers in brackets are estimates

From Kuhnke (1989).

Table 8

Relative Energy Intensity of the Canadian Pulp and Paper Industry, 1981*

	Pulp and paper	Total manufacturing
Cost per establishment ($000)	8,610	158
Cost per employee ($000)	18	4
Cost as % of manufacturing materials	24	5
Cost as % of manufacturing value-added	23	8
Cost as % of value of manufacturing shipments	11	3

*Based on current dollar cost of purchased fuel and electricity.

From Battle (1986).

wrapping paper to 5.9% for culture paper (paper for printing and publishing, excluding newsprint, tissue aand sanitary papers). The base projected rate of growth to 2000 ranges from 0% for wrapping paper to 3.3% for culture paper (see Table 9). Appendix III provides detailed data on consumption of forest products obtained from Roberts and Luck (1985).

3.2.3 Overall Efficiency of Forest Resource Management: The Input/Output Balance

The Economics Branch (1988) reports an increase of 74% in Canada's production of industrial roundwood from 1960 to 1983. For the same period, Roberts and Luck (1985) show increases in domestic consumption of forest products as follows:

- softwood lumber--70%
- hardwood lumber--197%
- panel products (including plywood, particle board and waferboard--217%
- newsprint--130%
- culture paper--272%
- wrapping paper--24%
- paperboard--104%
- building board--50%

Table 9

Average Annual Compound Rate of Growth
in Canadian Consumption of Forest Products
(1960-1980, with Projections to the Year 2000)

	1960-1980	1980-2000		
		Pessimistic	Base	Optimistic
Softwood Lumber	1.9%	1.1%	1.3%	1.5%
Hardwood Lumber	2.6%	1.9%	2.3%	2.5%
Panel Products	5.3%	2.3%	2.6%	2.8%
Newsprint	4.1%	1.6%	1.7%	1.9%
Culture Paper	5.9%	3.0%	3.3%	3.6%
Wrapping Paper	1.3%	0.0%	0.0%	0.0%
Paperboard	3.4%	2.2%	2.5%	2.7%
Building Boards	3.0%	2.2%	2.4%	2.5%

From Roberts and Luck (1985).

Wille (1988) shows an approximate balance between Canadian imports of roundwood (2% of total production) and exports (1.7%). Thus the roundwood production and forest product consumption figures given above indicate a significant increase in the efficiency of conversion of raw material to finished products over the 23 year period.

Pest damage and pest control are major factors in Canada's wood supply and its forest management programs. Thus some measure of the effectiveness of pest control would be a useful tool in evaluating the efficiency of forest management (pesticides represent resource inputs in production of forest products, and pest damage reduces the amount of raw material potentially available to industry).

Swift (1983) questions the value of using pesticides against spruce budworm, saying that the area of budworm infestation in New Brunswick increased during a long-term control program, while the affected area in Nova Scotia decreased in the absence of controls. This suggests that one measure of the efficiency of resource use would be the ratio of the area of forest pest damage to the area of pest control. However, applying such an equation in a meaningful way would require a large amount of data for an extended period. And the calculations should accommodate such factors as geographic and seasonal differences in pest and forest characteristic, and external natural and human

influences on pest populations and behavior. The available data are not sufficient to apply a suitable indicator.

However, information provided by Forestry Canada gives a partial view of trends in pest damage and pest control (see Table 10). From 1980 to 1986, both the area of pest damage and the area sprayed showed an overall decline (66% for the former and 58% for the latter). This trend occurred during a period where there was decreasing use of chemical pesticides and increasing use of the biological control agent Bacillus thuringiensis (B.t.). See Section 3.3.1.

The energy efficiency of Canada's pulp and paper industry increased during the period of 1976 to 1984, and mills made substantial savings in the area purchased fuel, due to the increasing use of process and wood wastes to supplement other energy sources (see Table 11).

Battle (1986) uses an index of energy intensity based on energy consumption per unit of mill output (gigajoules of input energy per tonne of physical output). The indesx assigns a value of 100 to the base year, 1972. In kraft pulp production, energy intensity for purchased fuels declined from 91.4 in 1976 to 66.9 (a 27% reduction), and for all fuels, from 98.6 to 93.1 (6%). For newsprint production, energy intensity for purchased fuels declined

Table 10

Area of Moderate to Severe Defoliation and Aerial Spraying to Control the Spruce Budworm in Canada (1980-1986)

Year	Pest Damage (area of moderate to severe defoliation)	Pest Control (area sprayed)
	1,000,000 ha.	
1980	36.2	1.9
1981	37.0	2.9
1982	18.2	3.0
1983	23.8	3.1
1984	16.8	2.0
1985	20.2	1.5
1986	12.3	0.8

From Kondo and Taylor (1986) and Kondo and Moody (1987).

Table 11

Indexes of Energy Intensity for the Canadian Pulp and Paper Industry
(1972 = 100.0)

Year	Kraft pulp		Newsprint	
	Purchased fuels	All fuels	Purchased fuels	All fuels
1976	91.4	98.8	98.8	98.1
1977	84.9	100.8	93.8	95.6
1978	82.0	101.3	92.5	96.0
1979	84.6	99.1	87.3	93.0
1980	80.7	95.4	85.8	91.4
1981	81.2	96.7	83.9	90.2
1982	78.2	97.9	87.2	93.5
1983	65.5	92.2	83.3	92.2
1984	66.9	93.1	81.0	92.4

From Battle (1986).

from 98.8 in 1976 to 81.0 in 1984 (18%), and for all fuels, from 98.1 to 92.4 (6%).

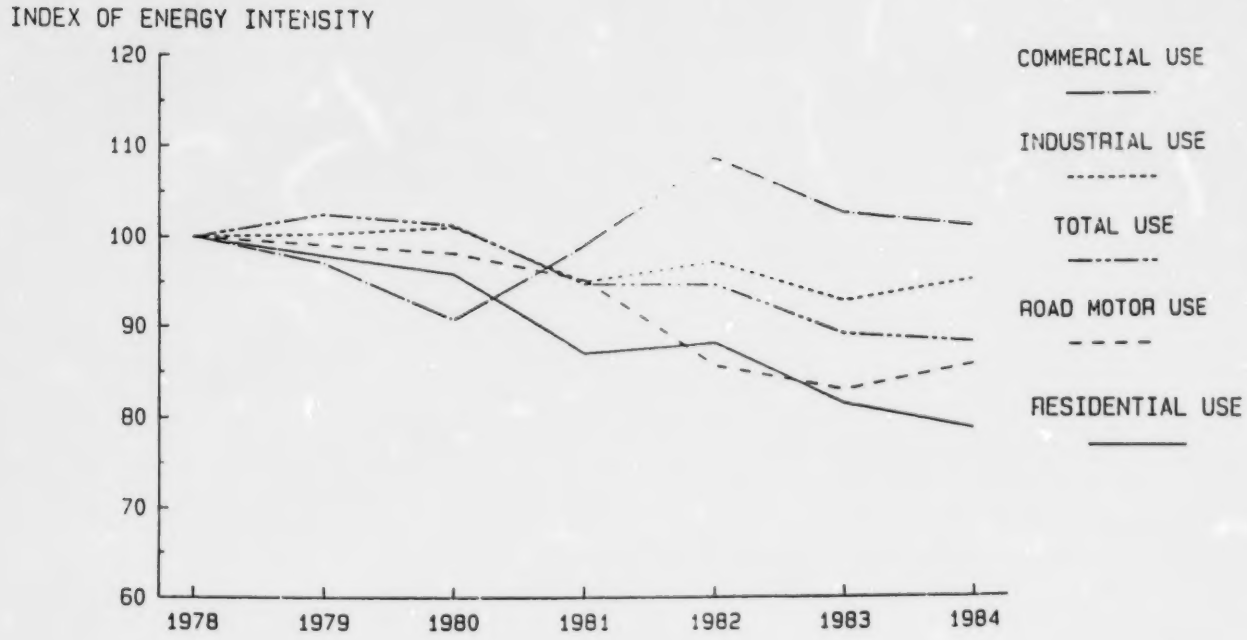
These values for the pulp and paper industry can be placed in a broad perspective with a look at Figure 7. The achievements in the pulp and paper sector compare favorably with the modest decline in energy intensity shown for all industrial use and the slight increase in intensity for total energy use.

Wille (1988) describes trends in roundwood consumption and recycling for the pulp and paper industry:

> Flexible cellulose fibre--the principle ingredient of paper--stems basically from four sources: (1) roundwood, (2) wood residues, (3) non-wood fibres and (4) recycled fibres.
>
> Over the years, the proportion of roundwood continuously declined from 54% in 1978 to 49% at the present time. Vice versa, the input of wood residues, and to a lesser extent the input of recycled paper increased. Residues accounted for only 10% in the early 1960's and the tremendous increase in subsequent years represents one of the most significant developments in the forest industry....
>
> Many sawmills, plywood and veneer plants still operate at a very low yield and too much wood is converted into low-value residues. We believe that on the average for the wood processing industries, the portion of the final product could be raised by 5% to 10%, merely by implementing certain efficiencies in processing....In some areas of Canada the proportion of dumped or burned residues reaches almost one half.

Figure 7

Intensity of Energy Use in Canada



Sources: StatsCan 57-003, 61-213, 53-219, and 13-567

From Battle (1986).

Wille (1988) describes a significant potential for further benefits from paper recycling. He estimates that a tonne of recycled paper is equivalent to 20 trees, and Canadians could go much further with recycling efforts to date. Although exact figures are not available, he states that current recovery rates are less than 30% in this country, compared with 82% in Japan and 50% for most central European countries.

3.3 Environmental Effects of Forestry

The ecological role of forestry is complex and not fully understood. The data base is simply not adequate to identify the nature and degree of impacts except in the most general way. However, it is safe to say that, due to the size of the forest industry and the huge area of land affected by forestry activities, the environmental implications of the sector are profound.

Hundreds, if not thousands, of different indicators would be needed to provide an accurate overall picture of environmental conditions and trends related to Canadian forestry. This section lists a few of those indicators for which some data are available and which can reliably reflect conditions and trends related to certain aspects of

forest extraction and processing. These are:

1) the relative amount of use of chemical pest control and non-chemical control;

2) the relative amounts of use of different logging techniques--clearcutting, shelterwood and selection cutting--these differ in their potential environmental impact, although each can be applied with little adverse impact if applied properly to the appropriate forest site (Sharpe et al., 1976);

3) the relative amount of use of the different forms of chemical and mechanical pulp production processes--these differ significantly in the amount and toxicity of effluents;

4) water pollution control compliance levels of pulp and paper mills; and

5) pollutant loadings to water by pulp and paper mills.

3.3.1 Chemical Pest Control vs. Non-chemical Control

Growing environmental concern about chemical pesticides in recent decades has resulted in prohibition of use of some

of the more toxic chemicals and development of more selective and less persistent ones. There has been an increasing amount of research and development in biological control and increasing interest in integrated pest management (IPM). IPM combines biological and chemical controls in an effort to reduce dependence on the latter.

Among the concerns about pesticides are the large number of compounds which may be involved and the uncertainty of their behavior in the environment. Chemicals entering the environment from pesticide use include not only the registered chemicals themselves, but the many different commercial formulations which are on the market, the non-pesticide components of spray formulations and metabolites and products of chemical breakdown in the environment. Thus there are potentially thousands of substances of environmental concern, and the understanding of their nature and effects is limited (Ernst, et al., 1981; Hall, 1981; Versteeg, 1984).

Ernst et al. (1981) express concern about environmental impacts of the transportation, storage and handling of pesticides and the many potential hazards where large numbers of people are involved in a variety of operations. They report on federal Environmental Protection Service

inspections in eastern Canada:

> At times unnecessary and unacceptable quantities of of spray chemicals have been released with little regard for the receiving environment. Criticism and pressure by EPS have, in recent years, led to substantial correction to procedures and attitudes and have resulted in substantial reductions in the amount of spray chemicals entering the environment incidentally.

The widespread concern about chemical pesticides suggests that a trend toward more target-specific, non-chemical control agents is a move toward sustainable development.

Although many non-chemical control agents are being investigated for forestry use, B.T. is the only one which has been used in major forestry programs. B.t. is a bacterial strain which works in the gut of lepidoptera (moths and butterflies) to disrupt the insects' feeding cycles. In recent years, this biological pesticide has become a major component of Canadian control eforts for the spruce budworm.

Spruce budworm spraying has been the largest component of Canada's forest pest control efforts for much of recent history: Kuhnke and Brace (1986) report that New Brunswick and Quebec, which have had the most active budworm spray programs, together accounted for more than 97% of forest pest control in Canada for the period 1975 to 1982.

Therefore it is not surprising that much of the available pest control information relates to the budworm.

Table 12 shows the area sprayed and the relative use of chemical controls and B.t. from 1979 to 1986 for eastern Canada. The area sprayed with chemicals declined from 99% to 71% of the total area over the seven year period. These figures from Dunster (1987) appear to conflict with those in Table 10, obtained from Kondo and Taylor (1986) and Kondo and Moody (1987). These discrepancies in forestry statistics from different authorities are a recurring problem, and are cited here as additional evidence to support caution in any conclusions based on Canadian forestry data.*

Whichever figures are the more accurate, the area of spruce budworm spraying is reported to have declined by 47% (Dunster, 1987) to 58% (Kondo and Taylor, 1986; Kondo and Moody, 1987). The decline in total area sprayed and the decline in use of chemicals are both favorable environmental indicators.

---

*Kondo and Taylor (1986) and Kondo and Moody (1987) include some data for budworm spraying in western and northern Canada, While Dunster (1989) stated that figures cited by Dunster (1987) may include some jack pine budworm spraying. However, these differences alone would not account for the large discrepancies in the reported data.

Table 12

Spruce Budworm Spraying in Eastern Canada (Ontario, Quebec, New Brunswick, Nova Scotia and Newfoundland): 1979-1986

Year	Chemicals ha. (% of total area)	*Bacillus thuringiensis* ha. (% of total area)	Total area ha.
1979	2,183,526 (99)	27,115 (1)	2,210,641
1980	1,775,405 (96)	74,485 (4)	1,849,890
1981	2,831,471 (98)	54,671 (2)	2,886,142
1982	2,999,159 (98)	62,823 (2)	3,061,982
1983	2,765,457 (97)	79,416 (3)	2,844,873
1984	1,599,709 (81)	384,930 (19)	1,984,639
1985	848,822 (57)	645,130 (43)	1,493,952
1986	826,104 (71)	339,014 (29)	1,165,118

From Dunster (1987)

Figure 8 provides a graphic illustration of the trends in relative use of chemicals and B.t.

3.3.2 Relative Amount of Use of Different Logging Methods

Logging is carried out in a variety of ways in accord with three basic sylvicultural systems: clearcut, selection and shelterwood. Each of these systems has variations within it and was developed for use in particular types of forests on particular sites.

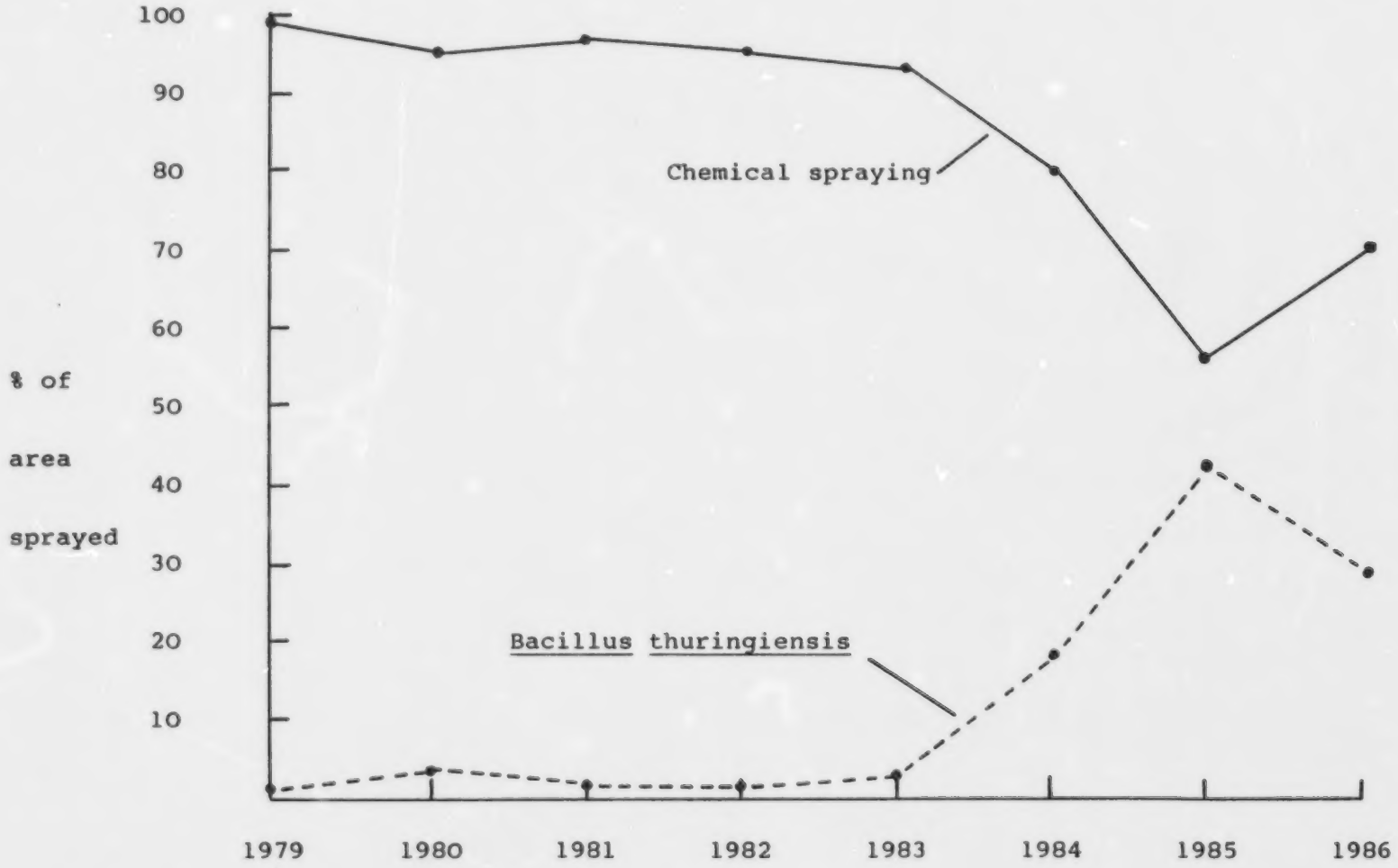
The sylvicultural role of logging is to remove some or all of the mature timber while creating space, light, and in some cases suitable soil surface conditions, for tree reproduction. Thus appropriate and properly applied logging techniques are intended both to remove one crop and help establish another one.

Clearcutting

In clearcutting, the entire existing forest is removed. It is suitable for tree species which reproduce in the open on the particular site to be logged without any modification of the environment by other vegetation. Thus clearcutting as a sylvicultural system is intended to be used for

Figure 8

Spruce Budworm Spraying in Eastern Canada
(Ontario, Quebec, New Brunswick, Nova Scotia and Newfoundland): 1979-1986



From Dunster (1987).

pioneer or shade-intolerant (termed "intolerant" by foresters) species which commonly reproduce in abundance following large natural disturbances, particularly fire.

Clearcutting is certainly the most controversial of the logging systems, perhaps largely due to the adverse esthetic impact of stripping whole forests from the landscape. But undoubtedly the most serious environmental concerns in clearcutting arise from its improper use. It has been applied over large areas in the wrong forests on the wrong sites, on steep slopes, without regard for wildlife and without adequate sylvicultural imput to ensure that a new and productive forest replaces the one which was removed. These problems are often aggravated by road-building techniques which increase the risk of erosion and loss of site productivity,

Sharpe et al. (1976) state:

> Clearcutting as a sylvicultural system is... uniquely vulnerable to abuses. Effects of carelessness or unwise practices that may not be evident under other harvesting systems become highly visible with clearcutting. Slash is more of a problem and can be a fire hazard and an eyesore for many years if not disposed of. Clearcut areas are often too large, accentuating the impression of ecological desolation. The system has been misapplied to forest types and stand conditions which called for some other method, resulting in poor utilization, destruction of growing stock, and regeneration failure. Where artificial regeneration was required, site preparation

to ensure planting success has often been crudely done, leaving ugly and persistent scars. If care is not taken clearcutting operations tend to steamroller indiscriminately through patches of young growth, small streams, good wildlife cover, or other natural enclaves which should be left intact.

Selection Cutting

The selection system involves removing individual trees within a stand. Group selection, a modification of the system, involves cutting small groups or patches of mature timber within the stand.

Selection cutting is appropriate for reproduction of shade-tolerant tree species typical of late successional or climax forests and in cases where minimal disruption of the existing forest is desired. Selection cutting is often popularly referred to as "selective" cutting, although the latter term can also be a euphemism for high-grading.

The Shelterwood System

Shelterwood cutting, which has a number of variations, involves partial cutting of a stand to allow space for reproduction while the trees which remain provide a "shelter" of shade and microclimate and and a source of seed for the new forest. After the young trees are

established, the remaining trees of the old stand are removed in one or more succeeding cuts. Variations in the layout, scheduling and intensity of cutting make the shelterwood a particularly versatile sylvicultural system applicable to a wide variety of forests and sites.

The strip shelterwood is one variation of the shelterwood which involves cutting all trees in strips run through a stand. The strips are sufficiently narrow that adjacent uncut trees provide partial shade or shelter for the new crop which is established on cutovers.

Sharpe et al. (1976) suggest that the shelterwood system may provide conditions most similar to forest depletion and renewal in the absence of human intervention:

> Quite possibly, much successful natural reproduction in forests occurs in what is essentially a shelterwood environment. Natural disturbances which open up the stand occur so frequently that selection-type environments are not sustained for long periods of time, a fact attested to by the relative scarcity of climax forest stands. At the same time, most natural disturbances rarely result in as complete a removal of the existing stand as does clear-cutting. Even a forest of dead trees, following a catastrophic fire or insect epidemic, has some sheltering effect for ensuing reproduction.

This comparison of logging methods suggests that environmentally sound forest harvesting could involve the use of all three of the basic silvicultural systems,

including a number of variations of each to suit the characteristics of individual forest sites. In Canada however, clearcutting is certainly the dominant method.

Table 1 shows that the area of forest harvesting in Canada increased by 32% from 1875 to 1985. Over the same period, the portion of the total which was clearcut increased from 84% to 90%. While these figures cannot be directly interpreted in terms of the impact on the environment, the overwhelming dominance of clearcutting, coupled with the increase in area logged should stimulate concern. Is clearcutting the best approach in all cases where it is currently used? Are environmental standards for size, shape, location and timing of cuts adhered to? What are the long term consequences for site productivity, wildlife habitat and surface water quality? These important questions are difficult if not impossible to answer with our present information base.

3.3.3 Amount of Use of the Different Forms of Chemical and Mechanical Pulp Production Processes

Wille (1988) provides an overview of the major types of pulp production processes:

> Pulp may be considered a partially processed raw material, midway between the tree and the end product, that is paper or paperboard. The purpose of all pulping processes is to separate the wood

into individual fibres, parts of fibres, small fibre bundles or fragments. Subsequently, they are freed of contaminants by washing and screening. The pulp slurry is then recombined into continuous sheets of paper or paperboard.

Wood can be separated into fibres by (a) mechanical or (b) chemical means, or (c) a combination of both. Some 98% of all pulps in Canada are produced by either one of these three methods. A further 2% is defibrated or exploded pulp, and dissolving grade & special alpha pulp. Each pulping method gives a pulp with unique properties.

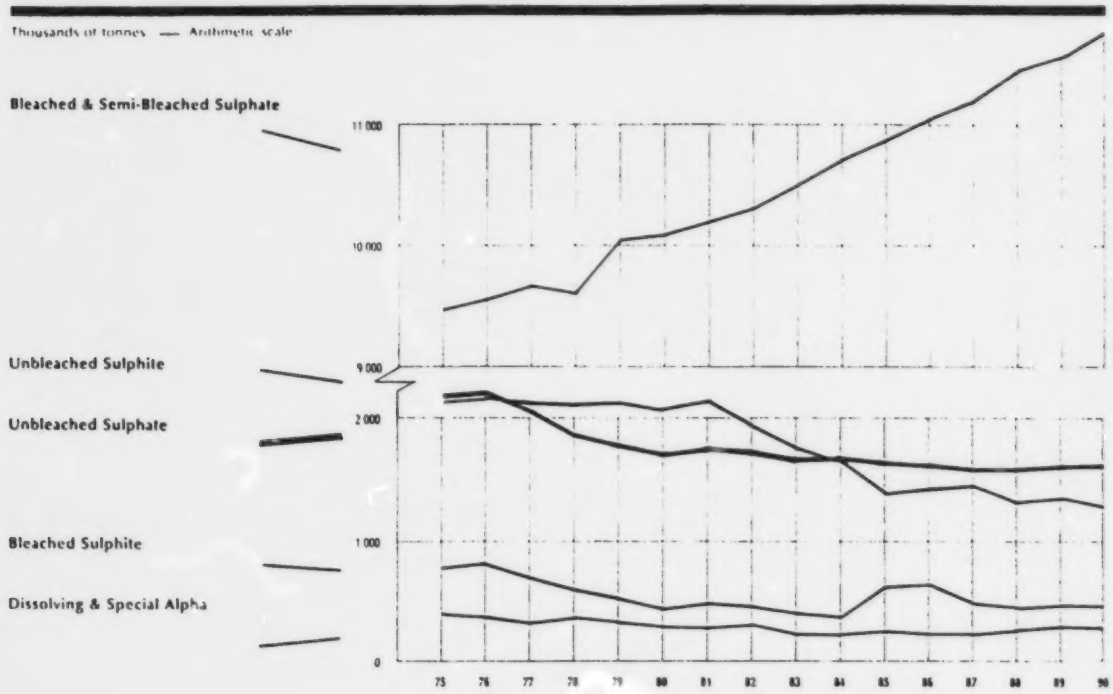
Chemical pulping includes the sulphite and kraft (sulphate) processes. Wille (1988) reports that chemical pulping makes inefficient use of raw material, often yielding less than 50% of the dry weight of wood entering the process. In the sulphite process, the wood is cooked in a bisulphite-sulphurous acid solution to yield a pulp suitable for a wide variety of paper products. Pollution is a major drawback of the sulphite process, because there are large releases of wood fibre and processing chemicals, particularly with older mills. The use of sulphite processes has been declining for several years (see Figure 9).

Use of the kraft process has been growing steadily in recent years (see Figure 9). This process uses a highly alkaline solution of sodium hydroxide and sodium sulphide to dissolve the lignin from the wood raw material. Its advantages include: 1) process chemicals can be recovered

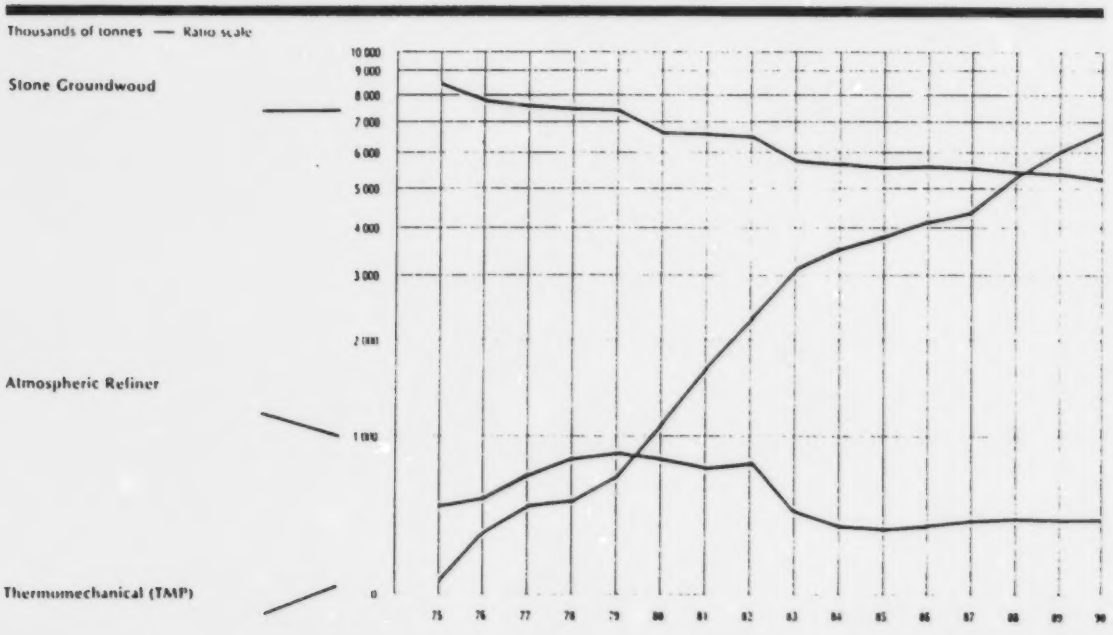
Figure 9

Canadian Wood Pulp Processing Trends

Chemical Pulp
— Annual Capacity 1975-1990



Mechanical Pulp
for Paper & Paperboard 1975-1990
— Annual Capacity



From Canadian Pulp and Paper Association (1988)

economically; and 2) the recovery system reduces the discharge of organic pollutants.

A major concern about the kraft process is the dioxin in mill effluents. Traces of dioxins and furans have been found in a number of water bodies near Canadian mills (Wille, 1988).

Mechanical pulping includes the stone groundwood and refiner methods. With each of these, the raw material is ground and torn to yield wood fibre and fibre fragments. A relatively new version of the refiner process is thermomechanical pulping or TMP. TMP is less damaging to wood fibres than other mechanical methods, yielding better quality paper, although the energy costs are reported to be relatively high. Figure 9 shows the rapid growth which has occurred with the TMP process.

Mechanical pulping methods have the advantage of better wood fibre utilization levels and reduced effluent pollution as compared with chemical pulping (Chung, 1985; Wille, 1988).

Semi-chemical pulping includes a variety of processes which involve partial chemical removal of lignin from wood chips, followed by mechanical refining methods. The efficiency of wood utilization is reported to be intermediate between the

chemical and mechanical processes. Chemi-thermomechanical pulping (CTMP) is one new variation of semi-mechanical pulping which is increasingly used in Canada. A disadvantage of this process is its high electricity consumption--up to three times that of the bleached kraft pulping process (Wille, 1988).

Wille (1988) lists four different categories of pulping processes in descending order of environmental cleanliness:

1) pulping of recycled paper;
2) mechanical pulping;
3) kraft (sulphate); and
4) sulphite.

Figure 9 shows a significant increase in the more environmentally benign processes relative to the least desirable sulphite process.

Sinclair (1988) documents the general trend toward more environmentally benign pulp production in a comparison of tonnage output by different production methods from 1950 to 1984. He ranks the "environmental sensitivity" of nine different processes, with the dissolving and special alpha process rated most stressful for the environment and the groundwood process being least stressful. The general decline in use of the more disruptive processes relative to

the less harmful ones is apparent in Tables 13-A and 13-B. However, Sinclair (1988) points out that the environmental performance of the industry has varied over the years, and the newer technologies have not always been cleaner than the ones they have replaced. He describes two important and often conflicting trends which are major determinants of the environmental impact of the industry:

- the move to develop stronger, brighter, better quality pulps; and

- the drive to reduce production costs through more efficient manufacturing technology.

The former can often be a negative trend for the environment: higher quality pulp requires more processing, and thus tends to use more energy and produce larger amounts of waste.

The latter trend can have environmental benefits as new technologies lead to greater energy savings, more efficient use of a broader range of raw materials, increased recycling and reduced wastes.

Sinclair (1988) suggests that the interplay of these two trends has resulted in a somewhat erratic environmental performance by industry. Some of the more environmentally

Tab. 13-A

Wood Pulp Production (Output) according to Pulping Process and Environmental Sensitivity[1]: 1950 to 1970 (000's tonnes)[2]

	1950		1955		1960		1965		1970	
	#	%	#	%	#	%	#	%	#	%
Dissolving & Special Alpha	305	4.0	365	4.0	356	3.4	431	3.3	411	2.5
Sulphite Bleached	386	5.0	566	6.1	519	5.0	817	6.2	684	4.1
Sulphite Unbleached	1,315	17.1	1,625	17.6	1,560	15.0	1,836	13.9	1,870	11.2
Semi Chemical	94	1.2	141	1.5	203	2.0	177	1.3	295	1.8
Sulphate[3] Bleached	396	5.2	663	7.2	1,062	10.2	1,862	14.1	3,660	22.0
Sulphate Semi-Bleached	12	.2	55	.6	257	2.5	566	4.3	1,084	6.5
Sulphate Unbleached	548	7.1	617	6.7	896	8.6	1,114	8.4	1,341	8.1
Defibrated & Exploded	81	1.1	126	1.4	143	1.4	170	1.3	259	1.6
Groundwood	4,455	57.9	4,960	53.9	5,335	51.3	6,170	46.6	6,940	41.8
Not otherwise specified and Screenings	96	1.2	92	1.0	66	.6	77	.6	64	.4
	7,688	100.0	9,210	100.0	10,397	100.0	13,220	100.0	16,608	100.0

1 The production process categories are listed from top to bottom according to potential environmental impact. The most environmentally stressful are listed at the top with each successively less stressful production process listed sequentially down the process category column.

2 It should be noted that production totals in metric tonnes are not necessarily exactly the same as the totals published by CPPA due to rounding errors.

3 These rankings do not take into account the potentially disruptive influences of organochlorines.

From Sinclair (1988).

Table 13-B

Wood Pulp Production (Output) according to Pulping Process and Environmental Sensitivity[1]: 1975 to 1984 (000's tonnes)[2]

	1975		1980		1981		1983		1984	
	#	%	#	%	#	%	#	%	#	%
Dissolving & Special Alpha	226	1.5	271	1.3	274	1.3	169	.8	173	.8
Sulphite Bleached	516	3.4	463	2.2	488	2.4	360	1.8	435	2.0
Sulphite Unbleached	1,442	9.6	1,671	8.1	1,769	8.6	1,378	6.9	1,431	6.8
Semi Chemical	233	1.5	345	1.7	392	1.9	367	1.8	397	1.9
Sulphate[3] Bleached	4,219	27.9	6,580	31.8	6,278	30.5	6,745	33.7	6,894	32.7
Sulphate Semi-Bleached	863	5.7	1,185	5.7	1,009	4.9	1,053	5.3	1,100	5.2
Sulphate Unbleached	1,314	8.7	1,998	9.7	1,921	9.4	1,752	8.7	1,732	8.2
Defibrated & Exploded	263	1.7	384	1.9	311	1.5	260	1.3	275	1.3
Groundwood	6,007	39.8	7,748	37.4	8,085	39.3	7,913	39.5	8,647	40.9
Not otherwise specified and Screenings	28	.2	42	.2	44	.2	32	.2	39	.2
	15,111	100.0	20,687	100.0	20,571	100.0	20,029	100.0	21,123	100.0

1 The production process categories are listed from top to bottom according to potential environmental impact. The most environmentally stressful are listed at the top with each successively less stressful production process listed sequentially down the process category column.

2 It should be noted that production totals in metric tonnes are not necessarily exactly the same as the totals published by CPPA due to rounding errors.

3 These rankings do not take into account the potentially disruptive influences of organochlorines.

From Sinclair (1988).

benign processes have been replaced by others which yielded better pulp at the expense of the environment. However, improvements in process technology have tended to reduce the environmental impact of any given processes over time.

3.3.4 Water Pollution from Pulp and Paper Mills

Sinclair (1988) offers a perspective on water quality impacts of the pulp and paper industry:

> ...pulp and paper manufacturing is considered one of the nation's most environmentally disruptive industries. According to government authorities across Canada, pulp and paper manufacturing ranks first as an environmental problem in New Brunswick and British Columbia. It ranks second in Newfoundland, and third in Quebec, Ontario, and Manitoba.

The pulp and paper industry uses enormous quantities of water in its production processes and to disperse its wastes. Sinclair (1988) points out that the abundant water supply provided by Canada's rivers has been a key factor in the growth the domestic pulp and paper industry, and these same waterways have carried the industry's polluntants across provincial and international boundaries.

The Ontario Ministry of the Environment (1989a) lists factors which contribute to the concern about mill discharges:

- they may contain large amounts of suspended solids which could be injurious to fish and aquatic life and which could settle out in the receiving waters, blanketing the bottom and rendering it inhospitable to to normal populations of benthic fauna;

- they may exert an excessive oxygen demand on the receiving waters, which could result in a depletion of dissolved oxygen concentrations;

- they may show acute toxicity to fish and other aquatic animals when tested in a laboratory;

- they may contain chemicals which are toxic to humans;

- they may contain chemicals which have been shown to have or may potentially have chronic (long term) toxic effects on fish and other aquatic life;

- they may contain chemicals which are known to be persistent (or are chemically similar to known persistent chemicals and therefore potentially persistent) and which will not break down in the environment in the short term;

- they may contain chemicals which are known to bio-accumulate in fish and other aquatic life;

- they may contain chemicals which are known carcinogens or suspected of being carcinogens due to their chemical similarity to known carcinogens;

- they may contain chemicals which are known mutagens or suspected of being mutagenic; and

- they may create problems of taste and odour in fish and drinking water supplies.

Table 14 lists compounds identified by the Ontario Ministry of the Environment as of concern in the effluents of pulp and paper mills.

Table 14

Parameters of Concern Identified in Pulp and Paper Mill Effluents

	RATIONALE FOR INCLUSION
TOTAL METALS	
Aluminum	Moderatley toxic, animal & suspect human carcinogen
Cadmium	Extremely toxic, moderately bioaccumlative
Copper	Toxic
Lead	Extremely toxic
Mercury	Extremely toxic, highly bioaccumlative
Zinc	Highly toxic
VOLATILES, HALOGENATED	
Bromodichloromethane	Mutagen
Carbon tetrachloride	Slightly toxic, animal & suspect human carcinogen
Chloroacetaldehyde	Mutagen
Chloroform	Slightly toxic, animal & suspect human carcinogen
Chlorofuranone	Mutagen
Chloropropenal	Mutagen
Dichloroacetone	Mutagen
Dichloroethane	Slightly toxic, animal carcinogen
Hexachloroacetone	Mutagen
Methylene Chloride	Mutagen
Pentachloroacetone	Mutagen
Pentachloropropene	Mutagen
Tetrachloroacetone	Mutagen
Tetrachloroethene	Mutagen
Tetrachloropropene	Mutagen
Trichloroacetone	Mutagen
Trichloroethane	Toxic, isomers 1,1,1-mutagen; 1,1,2-carcinogen
Trichloroethene	Mutagen
VOLATILES, NON-HALOGENATED	
Benzene	Moderately toxic, animal & suspect human carcinogen
Toluene	Moderately toxic, cancer promoter
Dimethyl Sulfide	USEPA parameter list
Dimethyl Disulfide	USEPA parameter list
EXTRACTABLES, BASE NEUTRALS	
Dibutyl phthalate	Human health risk
EXTRACTABLES, ACIDS (PHENOLS)	
2,4-dichlorophenol	USEPA parameter list
4,5-dichloroguaiacol	USEPA parameter list
2,4,5-trichlorophenol	USEPA parameter list
2,4,6-trichlorophenol	USEPA parameter list
3,4,5-trichloroguaiacol	USEPA parameter list
4,5,6-trichloroguaiacol	USEPA parameter list
2,3,4,6-tetrachlorophenol	High BCF
Pentachlorophenol	USEPA parameter list, high BCF
Phenol	Toxic, impair flavor of fish
2,3,4,5-Tetrachlorocatechol	High BCF
3,4,5,6-Tetrachloroguaiacol	USEPA parameter list, high BCF, high toxicity
DIOXINS AND BENZOFURANS	
RESIN AND FATTY ACIDS	
BCF Biocumulation Factor	

From Ontario Ministry of the Environment (1989a).

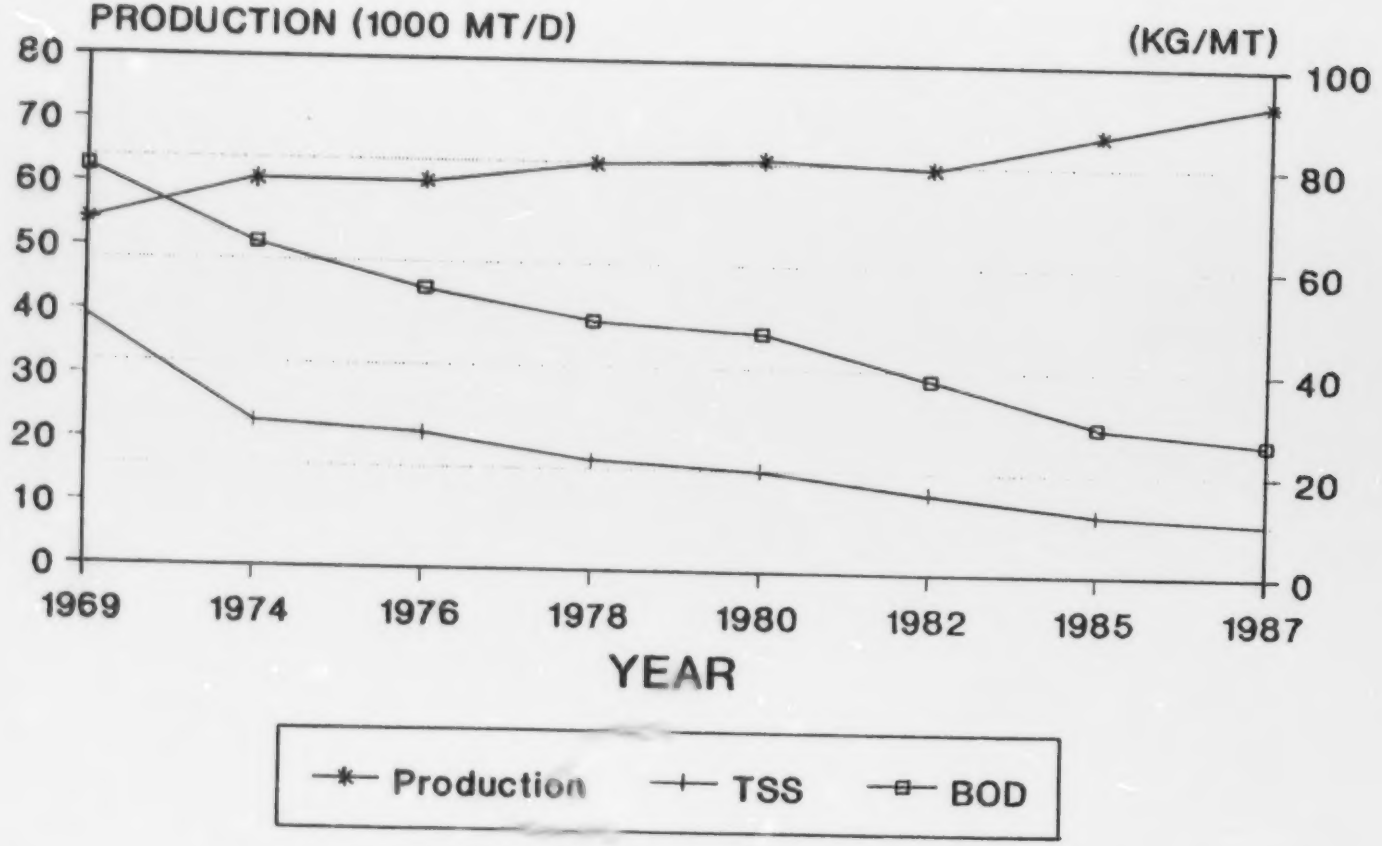
The kraft (sulphate) process, which comprises the bulk of Canadian pulp production has been a particular focus of attention due to the huge volume of effluents involved, chemical wastes from the bleaching process and recent concerns over traces of dioxins and furans in effluents. The Ontario Ministry of the Environment (1989b) says that the province's nine kraft mills together discharge almost one million cubic metres per day of effluents with an oxygen demand on receiving waters equivalent to that of raw sewage from a city of two million people.

In 1970, the federal government passed regulations under the Fisheries Act to establish pulp and paper mill discharge limits for suspended solids, biochemical oxygen demand (BOD) and acute toxicity (to fish).

The Industrial Programs Branch (1984 and 1989) reports that the pulp and paper industry has decreased its levels of certain water pollutants on a per tonne of production and in absolute terms in recent years. Figure 10 shows the levels of suspended solids and BOD associated with pulp and paper mills. The levels of both these water pollution measures per unit of production were reduced by more than half between 1969 and 1987. Table 15 shows that, for the period of 1969 to 1982, total mill production increased from 54,250 to 63,687 tonnes per day, total suspended

Figure 10

Water Pollutant Discharge Trends
in the Canadian Pulp and Paper Industry (1969-1987)



From Industrial Programs Branch (1989).

Table 15

Production, Water Pollutant Discharge, and Pollution Control Compliance Levels in the Canadian Pulp and Paper Industry (1969-1986)

	1969	1978	1980	1982	1984	1986	Total Compliance *
Total Number of Mills in Canada	-	128	127	123	-	-	-
Production (tonnes per day)	54250	63922	64848	63687	-	-	-
Total Suspended Solids (tonnes per day)	2648	1388	1298	1014	973	973	655
Biochemical Oxygen Demand (tonnes per day)	4235	3132	3050	2439	2271	2271	1816

*Discharges which would occur if all mills complied with regulations under the federal Fisheries Act.

From Industrial Programs Branch (1984).

solids decreased from 2,648 to 1,014 tonnes per day, and BOD decreased from 4,235 to 2,439 tonnes per day.

Sinclair (1988) reports that, for the 122 mills discharging effluents directly into Canadian waters (without municipal treatment), acute toxicity releases decreased by 3,022,000 cubic metres, or 31 percent, from 1971 to 1985.

Tables 16 and 17 provide a measure of mills' pollution reduction performance based on data available in 1984. Table 16 gives a breakdown of suspended solids discharges and mills' federal Fisheries Act pollution control compliance levels for 1980 to 1982, with projections to 1986. Table 17 provides similar information for BOD levels.

The number of mills in compliance for suspended solids was expected to increase from 71 in 1980 to 100 in 1986, while the total number of mills in Canada decreased from 127 to 123. The compliance levels estimated for BOD_5 were an increase from 93 in 1980 to 104 in 1986. The estimated discharges of suspended solids in kg/tonne of production were 20 in 1980 and 14 in 1986. BOD_5 discharges in kg/tonne of production were 47 in 1980 and 35 projected for 1986. Thus, according to these measures, water pollution shows a positive trend for recent years.

Table 16

Suspended Solids Discharges and Compliance Levels for Canadian Pulp and Paper Mills

SUSPENDED SOLIDS DISCHARGES PROJECTED TO 1986

Region	Number of Mills*		Production	Number of Mills in Compliance				% of Production in Compliance				Suspended Solids Discharged kg/tonne of production**			
		1982	tonnes/day	1980	1982	1984	1986	1980	1982	1984	1986	1980	1982	1984	1986
Atlantic	19 (1)	20 (1)	9 219	10	12	13	13	55	61	71	81	21 (199)	19 (175)	19 (175)	19 (175)
Quebec	47 (8)	46 (7)	21 180	20	18	36	36	44	45	85	85	26 (556)	21 (446)	14 (299)	14 (299)
Ontario	29 (11)	28 (11)***	13 542	24	26	28	28	93	94	97	97	14 (200)	9 (122)	9 (122)	9 (122)
Northwest	7 (4)	7 (2)	2 800	5	5	5	5	71	100	71	71	13 (37)	11 (32)	11 (32)	11 (32)
Pacific	25 (2)	22 (2)****	16 946	12	12	15	18	43	43	55	55	19 (319)	14 (239)	14 (237)	14 (237)
Totals	127 (26)	123 (23)	63 687	71	73	97	100								
Weighted Averages								57	60	77	79	20 (1298)	20 (1014)	15 (973)	14 (865)

* Values in brackets under number of mills are those discharging to municipal treatment systems.

** Values in brackets are the corresponding tonnes TSS discharged per day.

*** Effluent from Kimberly Clark Kapuskasing mill is discharged to the Spruce Falls Power and Paper Co. Ltd. for treatment before discharge.

**** Prince George Pulp and Paper Ltd. and Intercontinental Pulp Co. Ltd. now have a common aerated lagoon before discharge and are considered as one mill for the purposes of this report.

Note: Projections for 1984 to 1986 are based on written compliance programs with individual mills and assume that mills will achieve the limits prescribed in the regulations as a minmum. The status of the number in-compliance programs is only accurate at the time of writing this report. Projections do not include expansions or new mills.

From Industrial Programs Branch (1984).

Table 17

BOD_5 Discharges

and Compliance Levels for Canadian Pulp and Paper Mills

BOD_5 DISCHARGES PROJECTED TO 1986

Region	Number of Mills*		Production (tonnes/day)	Number of Mills in Compliance				% of Production in Compliance				BOD_5 Discharged kg BOD_5/tonne of production**			
	1980	1982		1980	1982	1984	1986	1980	1982	1984	1986	1980	1982	1984	1986
Atlantic	19 (1)	20 (1)	9 219	12	12	13	13	57	58	64	64	49 (465)	45 (414)	45 (414)	45 (414)
Quebec	47 (8)	46 (7)***	21 180	30	28	33	38	49	52	61	80	66 (1412)	53 (1122)	42 (898)	42 (898)
Ontario	29 (11)	28 (11)	13 542	22	21	24	24	78	72	87	87	51 (729)	37 (501)	37 (501)	37 (501)
Northwest	7 (4)	7 (2)	2 800	6	6	6	6	85	85	85	85	15 (43)	15 (42)	15 (42)	15 (42)
Pacific	25 (2)	22 (2)****	16 946	23	22	23	23	100	100	100	100	23 (387)	21 (360)	21 (360)	21 (360)
Totals	127 (26)	123 (23)	63 687	93	89	99	104								
Weighted								72	71	78	84	47 (3050)	38 (2439)	35 (2205)	35 (2205)

* Numbers in brackets are mills discharging to a municipal treatment system.

** Tonnes of BOD_5 per day is shown in brackets under kg/tonne of production.

*** CIP at Gatineau, Quebec, and two Masonite mills (Insulation Board and Hardboard) are considered as one mill for purposes of this report as there is a common clarifier and outfall.

**** Prince George Pulp and Paper Limited, and Intercontinental Pulp Company Limited are considered as one mill because they have a common secondary treatment system.

From Industrial Programs Branch (1984).

Sinclair (1988) summarizes the pollution control performance of the industry:

> Despite substantial progress in reducing effluent discharges, the level of effluent loadings varies considerably among mills. Performance varies both with respect to absolute loadings levels and in the reductions achieved over time. A breakdown of the the distribution of production output, TSS [total suspended solids] BOD, and acute toxicity among the 122 direct discharge mills was undertaken. This examination shows that high production mills are not always the highest loadings mills. It shows that many mills are performing well environmentally. It also shows that a few mills account for a very large proportion of the total effluent loadings.

Toxic Chemicals in Mill Effluents

Sinclair (1988) states that "the release of toxicants is considered by many as the most threatening waste resulting from the production of pulp and paper." The Ontario Ministry of the Environment (1989a) points out that the large number of chemicals of concern stems from the fact that the wood raw material contains a wide variety of chemicals. many of these substances are released, and new chemicals are produced, during the pulping and bleaching processes. Chemical groups of environmental concern include resin and fatty acids, the chlorinated organics which are produced by the bleaching process, sulphur compounds, phenolics and metals (see Table 14). The chlorinated organic compounds alone account for some 300 of

the chemicals which have been identified in kraft mill effluent (Ontario Ministry of the Environment, 1989b). Although knowledge of the environmental impacts of chlorinated organics is limited, they have been found to be persistent and bioaccumulative (Sinclair, 1988).

A recent phenomenon of concern is the discovery of dioxins in kraft mill effluents. Sinclair (1988) states that "despite many statements of alarm...very little is known about the threat" of these chemicals. Dioxin concentrations which have been reported are in the parts per trillion to parts quadrillion range, a level of concentration which was undetectable until fairly recently (Ontario Ministry of the Environment, no date; Sinclair, 1988).

3.4 Genetic Conservation

One concern regarding the sustainability of forestry is the condition of the genetic base of the resource. Who knows what are the long term effects on the gene pool from continued extraction of trees, planting of selected genotypes, and other changes in natural habitats? Certainly not enough is known about the condition of the gene pool to be certain which forestry practices are harmful, which are benign, and what specific changes must

be made. In the absence of such knowledge, one form of insurance is to establish parks and other protected areas to maintain different forest ecosystems and thereby conserve the genetic material they contain.

Thus one measure of the sustainability of forestry is the degree to which the range of Canadian forest types are represented in protected areas. Since the likelihood of loss of genetic material is greatest with rare or threatened species, a related measure of sustainability is the degree to which particular identified rare or threatened species are included in parks or reserves.

Neither of these measures appears to have been applied to date by researchers involved with Canadian protected area programs, although both could apparently be developed with some effort. There are several projects under way which could help provide the needed information:

- Rubec (1989) is preparing a registry of ecological areas, on behalf of the Canadian Council on Ecological Areas. The registry is to include some 400 sites, with a standardized description of each. The registry may be organized by ecoregion, with an estimate of the percentage of each region which is included in protected areas.

- Hackman (1989) says that the Endangered Spaces project of the World Wildlife Fund Canada includes a survey of the provinces to determine their progress to date in achieving provincial park system planning targets. Results of the study will be reported in a book to be published by the fall of 1989.

- Finkelstein (1989) described the work of the Canadian Parks Service for the 1991 State of the Environment Report for Canada. His project involves use of the SPANS geographic information system to compile statistics on ecological reserves, provincial parks and national parks. He expects to relate this information to some type of land classification system--either the ecoregion/ecoprovince approach to be used in the SOE report or the Park Service's natural region system.

- Lloyd (1989) says that the Canadian Wildlife Service has mapped habitat and occurrence data for species listed by the Committee on the Status of Endangered Wildlife in Canada. The data are computerized on a SPANS system. She says that the habitat information has not yet been related to protected area boundaries, but that this could probably done with little difficulty.

Mondor (1989) provided a general indication of the degree of protection offered to Canadian landscapes by the

national park system: Of 39 terrestrial natural regions, 21 are considered to be represented by the 34 existing national parks. One of 29 marine natural regions is represented by one marine park, and several other national parks include marine components.

The lack of information on the nature and extent of the gene pool contained within parks and other protected areas is a major impediment to an evaluation of the long term sustainability of Canadian forestry.

4. CONCLUSIONS

Section 3 described a number of trends which relate to the sustainability of Canadian forestry. This information is summarized in Table 18. There are several undeniably positive indicators, as well as some negative ones which should be of serious concern. But what can we conclude? Is our present use of forest resources sustainable? The available information does not support a definite yes or no. It can be concluded however that Canada does not have the required measures in place to ensure that forestry is sustainable. These measures include:

1) Nationwide environmental standards and related performance monitoring for forest harvesting.

2) A national inventory of forest types included in parks and other protected natural areas, with a strategy for filling gaps in the protected area system.

Is Canada running out of wood? Apparently not in the short term, but the increasing harvest levels and the increase in NSR lands are warning signs for the future. The increase in silvicultural activity is a positive sign. And the increased efficiency of the forest products processing industry suggests that the available wood will be used with

Table 18

Summary of Sustainability Trends in Canadian Forestry

Indicator	Trend*	Implications**	Comments
Harvesting and Renewal			
1) Amount of forest harvesting	↑	-	This is negative in the sense of increased pressure on the resource base, but it provides economic and social benefits.
2) Fire control effectiveness	↑	+	This has a positive effect on wood supply but could have adverse effects on fire-dependent plant and animal species and communities.
3) Reforestation treatments	↑	+	There has been a major increase in the area receiving reforestation treatments in recent years, but it is difficult to quantify the effect on the future wood supply.
4) Regeneration success	x	x	The rates of success for regeneration are an important factor in the long term wood supply.

* ↑ = upward; ↓ = downward; x = data are not sufficient to identify a trend;

( ) = an assumption in the absence of sufficient data to draw a firm conclusion.

** + = implies sustainable development; - = implies non-sustainable development.

Table 18 (cont'd.)

Summary of Sustainability Trends in Canadian Forestry

Indicator	Trend	Implications	Comments
Harvesting and Renewal			
5) NSR land	↑	-	The NSR lands are an important concern because they represent a significant depletion of Canada's forest resource base and may severely limit the long term wood supply.
6) Uncut reserve portion of allowable cut	↓	-	Allowable cut figures suggest that more wood could be harvested each year, but the annual harvest is approaching the prescribed limit.
7) Forest productivity	(↓)	(-)	Fraser et al. (1985) suggest that forest productivity is declining due to the long range transport of air pollutants.
Efficiency of Resource Use			
1) Silviculture inputs	↑	+	Silviculture activity has increased substantially in recent years. This should have a positive effect on the wood supply, but the magnitude of the effect is difficult to estimate.

Table 18 (cont'd.)

Summary of Sustainability Trends in Canadian Forestry

Indicator	Trend	Implications	Comments
Efficiency of Resource Use			
2) Pest control	↓	+	The decline in the amount of spruce budworm spraying represents a lower cost of pest control inputs to forest management.
3) Ratio of products to roundwood inputs for industry	↑	+	The increase in product output relative to the amount of roundwood consumed by industry corresponds with increased recycling and use of residues as raw materials for mills.
4) Wastes from industrial processes	↓	+	Water pollution rates are declining for the pulp and paper industry, while recycling and the use of residues and wastes for energy are on the increase.
5) Energy efficiency of pulp and paper mills	↑	+	Because the pulp and paper industry is a very large energy consumer, the recent increase in energy efficiency is a significant positive trend.

Table 18 (cont'd.)

Summary of Sustainability Trends in Canadian Forestry

Indicator	Trend	Implications	Comments
Environmental Effects			
1) Area of spruce budworm spraying	↓	+	Due to environmental concerns about the use of pesticides, the reduction in area sprayed is a positive trend.
2) Ratio of biological to chemical controls for spruce budworm	↑	+	The biological control agent Bt is widely considered to be more environmentally benign than chemical sprays. Thus its increased use is a positive trend.
3) Clearcutting as a percentage of total harvesting	↑	(-)	The overwhelming dominance of clearcutting in Canada (90% of the area logged) raises questions about the environmental consequences. The existing information base is not sufficient to determine whether the practice is suitable in all cases where it is presently used, or whether adequate environmental protection measures are in place.
4) Pulp and paper mills: trends in use of less environmentally harmful processes	↑	+	The sulphite process is declining in use while less harmful processes are increasing.

Table 18 (cont'd.)

Summary of Sustainability Trends in Canadian Forestry

Indicator	Trend	Implications	Comments
Environmental Effects			
5) Water pollution from pulp and paper mills	↓	+	Suspended solids and BOD levels are declining, with more mills in compliance with the Fisheries Act. However, the pulp and paper industry remains one of Canada's largest sources of water pollution, and toxic chemicals in mill effluent are a major concern.

increasing effectiveness. This suggests a very positive future if harvesting and renewal can be brought into balance. The rate of increase in silviculture treatments has been significant, but it cannot be proven that this will avoid a long term wood supply problem (we can't be certain that today's silviculture work will reverse the growth in the backlog of unreforested land).

The pulp and paper industry has made significant improvements in the efficiency of use of energy and wood raw material. The industry's huge energy demand and its historic role as a major polluter demonstrate that these trends must continue.

Recycling by industry and by consumers has increased in recent years, and there is room for substantial gains in this area.

4.1 Information Gaps

There are several problems with the forestry information base which hamper the evaluation of sustainability. The most serious of these are:

1) Forest inventories are inadequate at the national level--each province has its own approach; published data

may be 20 years old or more; the five-year national inventories cannot be compared with each other due to changes in the inventoried area and survey methods between inventories; and, since the national inventory is compiled from individual provincial inventories, there is significant information loss due to aggregation and standardization of data.

2) The small amount of national published wood supply information is out of date.

3) Information on forest regeneration success rates is minimal.

4) Statistics from different sources frequently conflict.

4.2 Avenues for Further Study

There is considerable room for further exploration of the sustainability of forestry. This could involve refining the application of the indicators used here as well as investigating other aspects of the forest sector. Some important areas of inquiry are:

1) A province-by-province analysis of the harvesting/ renewal/wood supply situation. These issues are most

important at the provincial and local levels, and the bulk of the relevant data are collected at these levels.

2) Analysis of provincial and territorial forestry laws and policies, with particular attention to provisions for multiple use of forest lands. Environment Canada's former Lands Directorate did some research in this regard in 1987 (see Petch, 1987). This work could be updated.

3) A detailed analysis of the role of protected areas in the conservation of forest gene pools. This should be related to the ecozone framework, to determine how effectively the existing sites maintain the range of landscape features of the country. The implications of park management regimes should be included in the analysis.

4) A survey of logging practices, including the state of development and application of standards for the size, shape, location and timing of cuts.

5) Analysis of the environmental implications of logging roads with a literature survey, and perhaps case studies to compare practices in different jurisdictions.

6) A review of research on forest site productivity to document any identified long term trends for Canada.

7) Analysis of wood utilization and recycling rates, at each stage from forest harvesting to the consumer.

8) An evaluation of alternative forest management scenarios in terms of their economic and social impacts, particularly at the community level (some 340 communities in Canada depend almost exclusively on the forest for their livelihood).

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APPENDIX I

SUSTAINABLE DEVELOPMENT INDICATORS FOR FORESTRY

This Appendix lists indicators of sustainable development in the forestry sector. The list is excerpted from a March, 1989 report: The Use of Indicators to Show the State and Recent Trends in Sustainable Development in Canada, prepared by Gregg Sheehy for the Strategies and Scientific Methods Division of Environment Canada's State of the Environment Reporting Branch.

Indicators

1) Area of forest harvesting vs. area of reforestation.

2) Chemical pest control vs. biological control and integrated pest management (IPM).

3) Relative amount of use of different logging methods (clearcutting, selection and shelterwood).

4) Size of clearcuts (hectares--averages or size range for different jurisdictions).

5) Amount of silviculture treatments (area treated or expenditures).

6) Area of unreforested backlog land (not satisfactorily restocked (NSR) land).

7) Ratio of the area of forest pest control to area of pest damage.

8) Volume of timber harvested (cubic meters).

9) Forestry inventory data: age-classes, volumes and species.

10) Species and age-class distribution in relation to the location of mills.

11) Distribution of forest productivity classes in relation to volumes of commercial tree species.

12) Use of sulphite process vs. thermo-mechanical pulping (TMP) or chemi-thermo-mechanical pulping (CTMP) in newsprint production.

13) Efficiency of pulp mills and sawmills in the use of raw material (variety in species used and size range in logs, and amount of waste generated).

14) Energy efficiency of pulp mills.

15) Water pollution control compliance levels of pulp mills (compliance with Pulp and Paper Effluent Regulations of the federal Fisheries Act; compliance with provincial regulations and guidelines).

16) Pollutant loadings to water by pulp mills.

17) Facilities and programs for genetic conservation (expenditures, area and number of programs and facilities):

- botanical gardens and herbaria
- ecological reserves, wildlife preserves and other protected sites
- nurseries and seed banks
- zoos.

18) Representation of Canadian ecosystems in parks, ecological reserves and other protected areas.

19) Distribution of endangered species and habitats in relation to parks and reserves.

APPENDIX II

GLOSSARY

GLOSSARY

Age class: any interval into which the age range of trees, forests, crops or stands is divided for classification and use. Also the tree, forest, crop or stand falling into such an interval.

Allowable cut: the volume of wood which may be harvested, under management, for a given period.

Chemithermomechanical pulp (CTMP): a category of pulp which is produced by a relatively new process in which wood chips are treated with chemicals prior to heating and mechanical defibration.

Cleaning: a cultural operation in stands, not past the sapling stage, of eliminating or suppressing undesirable (mainly woody) vegetation to favor the crop trees.

Clearcut: a silvicultural system in which the old crop is cleared over a considerable area at one time.

Cutover: an area of forest land from which some or all of the timber has recently been cut.

Depletion: the decrease in merchantable volume on a managed forest area.

Evenaged: of a forest, crop, or stand in which small age differences exist between individual trees.

Forest inventory: a survey of a forest area to determine such data as area, condition, timber, volume and species, for specific purposes such as planning, purchase, evaluation, management, or harvesting.

Growing stock: the sum (by number, basal area, or volumeØ of trees in a forest or specified part of it.

kraft (sulphate) pulp: a chemical wood pulp obtained by cooking wood chips at high temperature in a solution of sodium hydroxide and sodium sulphide.

Maturity: the stage at which a tree, crop or stand best fulfills the purpose for which it was maintained.

Maturity class: trees or stands grouped according to their stage of development from establishment to suitability for harvest. A maturity class may comprise one or more age classes.

Mechanical wood pulp: the production of fibres and fibre bundles by grinding wood with pulpstones or by mechanical refiners as opposed to chemical means.

Not Satisfactorily Restocked (NSR) Forest Land: lands that have failed to regenerate adequately within 10 years of harvest or destruction of the forest cover.

Paperboard: a general term describing sheets made of fibrous material 0,012 in. (0.3mm) or more in thickness.

Productivity

> Productive: forest land that is capable of producing a merchantable (marketable) stand within a reasonable length of time.
>
> Unproductive: forest land that is incapable of producing a merchantable stand within a reasonable length of time, and specifically having a site index rating of less than 5m at base age 50--includes muskeg, rock, barrens, marshes, meadow, etc.--within a forest land area.

Regeneration: the renewal of a forest whether by natural (self-sown seed or by vegetative means) or artificial means (sowing and planting). This term may also be used to describe the young forest itself.

Roundwood: sections of tree stems, with or without bark. Includes logs, bolts, posts, pilings and other products still "in the round".

Scarification: loosening the topsoil of open areas, or breaking up the forest floor, in preparation for artificial or natural regeneration.

Selection System: an uneven-aged silvicultural system where mature and/or undesirable trees are removed individually or in small groups over an area. Regeneration is generally natural.

Semi-chemical pulp: pulp obtained by mild treatment of wood chips by any of the chemical pulping processes, which remove only part of the lignin from the wood chips, followed by mechanical treatment to complete the separation of the individual cellulose fibres.

Shelterwood System: an even-aged silvicultural system where mature trees are harvested in a series of two or more cuts (preparatory, seed, removal, final) whether by cutting uniformly over the entire stand area or in narrow strips. Regeneration is natural.

Silviculture: generally, the science and art of cultivating forest crops, based on a knowledge of silvics (the study of the life history and general characteristics of forest trees and stands with particular reference to locality factors). More particularly, the theory and practice of controlling the establishment, composition, constitution and growth of forests.

Site Preparation: disturbance of the forest floor and the topsoil to create suitable conditions for natural or artificial regeneration by mechanical or chemical means or by prescribed burning.

Site quality: a measure of the relative productive capacity of a site for one or more species.

Stand: a community of trees possessing sufficient unifromity in composition, constitution, age, arrangement or condition to be distinguishable from adjacent communities.

Stand Tending: generally, any operation carried out for the benefit of a forest crop at any stage of its life, e.g., cleaning, thinning, pruning; typically in an even-aged forest.

Stocking: a qualitative expression of the adequacy of tree cover on an area, in terms of crown closure, number of trees, basal area or volume, in relation to an established norm. In this context, tree cover includes seedlings and saplings, hence the concept carries no connotation of a particular age. Degree of stocking may be classified as:

- stocked versus nonstocked;
- understocked, fully stocked or overstocked; or
- as a percentage of the established norm or stocking factor.

Sulphate (kraft) pulp: see kraft pulp.

Sulphite pulp: a chemical wood pulp obtained by cooking wood chips in a bisulphite-sulphurous acid solution.

Thermomechanical pulp (TMP): a high-yield pulp produced by a process in which wood particles are softened by pre-heating under pressure prior to a pressurized refining stage. TMP usually replaces or reduces the chemical pulp component in newsprint or groundwod papers.

Thinning: a felling made in an immature stand, primarily to accelerate diameter growth, but also, by suitable selection to improve the form of the trees which remain.

Unevenaged: of a forest, crop or stand in which intermingling trees differ markedly in age.

Waferboard: a type of particleboard composed of wafers cut from roundwood bolts (mostly poplar) of uniform length and thickness resembling small pieces of veneer. The wafers are bonded together with resin binder, under heat and pressure, by a process similar to that by which particleboard is made.

Wood volume: volume of the wood of the main stem of trees or stands.

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APPENDIX III

CANADIAN FORESTRY SERVICE DATA

ON DOMESTIC CONSUMPTION OF FOREST PRODUCTS

1960-2000

INTRODUCTION

The material in this Appendix was excerpted from Roberts, D. and D Luck (1985) Canada's Domestic Consumption of Forest Products: 1960-2000. Information Report E-X-35, Economics Branch, Canadian Forestry Service, Ottawa.

Table III.1 Apparent Domestic Consumption: Historical Series

Year	Lumber		Panel* products
	Softwood	Hardwood	
	('000 m^3)		
1983P	13 182	1 999	3 160
1982	7 509	663	2 194
1981	12 075	961	3 380
1980	11 321	1 119	2 785
1979	11 510	1 300	3 256
1978	10 343	1 068	3 044
1977	10 181	1 002	3 098
1976	11 206	1 167	3 321
1975	10 660	977	2 566
1974	11 338	1 223	2 279
1973	10 849	1 382	2 260
1972	9 754	1 206	2 149
1971	9 472	933	1 930
1970	7 899	935	1 617
1969	9 203	1 025	1 746
1968	8 640	1 057	1 654
1967	8 745	1 048	1 545
1966	9 362	933	1 537
1965	9 219	964	1 446
1964	9 059	951	1 369
1963	8 208	851	1 344
1962	7 944	743	1 229
1961	7 569	753	1 175
1960	7 733	672	997

* Includes softwood and hardwood plywood, particleboard and waferboard.

P Preliminary estimates.

Sources: Statistics Canada. Various years. Catalogue Numbers 35-001, 35-002, 35-003, 35-204, 35-206, 36-003, 65-202 and 65-203.

Table III.1. Apparent Domestic Consumption: Historical Series (cont'd)

Year	Newsprint	Culture paper	Wrapping paper	Paperboard	Building board
			('000 tonnes)		
1983[P]	1 017	1 746	313	1 917	288
1982	935	1 566	326	1 766	226
1981	1 042	1 625	319	2 042	314
1980	982	1 485	326	1 858	335
1979	971	1 419	370	1 965	336
1978	908	1 296	375	1 839	381
1977	824	1 133	326	1 620	321
1976	803	1 046	372	1 759	387
1975	784	838	300	1 528	357
1974	804	1 035	429	2 069	430
1973	779	927	381	1 999	408
1972	709	867	365	1 729	377
1971	654	845	381	1 538	357
1970	649	767	358	1 492	301
1969	642	755	387	1 562	329
1968	612	713	343	1 454	295
1967	579	635	339	1 426	264
1966	563	638	345	1 377	244
1965	536	553	311	1 317	238
1964	499	539	297	1 204	239
1963	474	545	282	1 103	239
1962	463	500	269	1 034	222
1961	446	484	252	964	192
1960	442	469	252	940	192
1959	429	448	254	939	181
1958	394	413	232	908	178
1957	414	398	232	892	146
1956	433	398	240	937	156
1955	391	345		820	
1954	382	315		791	
1953	361	285		813	
1952	335	257		690	
1951	326	290		749	
1950	322	257			
1949	338				

Sources: Canadian Pulp and Paper Association, 1983. Reference Tables 1983. Montreal, P.Q., and personal correspondance with C. Ellingsen (CPA)

Statistics Canada. Various years. Catalogue Numbers 65-202 and 65-203.

BASE SCENARIO

Table III.3. Canadian Consumption Forescasts of Forest Products 1984-2000

Year	Paperboard	Wrapping Paper	Newsprint	Culture paper	Building boards	Panels	Lumber	
							Hardwood	Softwood
			('000 tonnes)				('000 m^3)	
1984	1 992	347	964	1 510	378	3 723	1 363	13 454
1985	2 050	348	989	1 575	388	3 760	1 237	11 417
1986	2 078	342	1 003	1 612	393	3 606	1 120	10 915
1987	2 145	343	1 031	1 685	403	4 177	1 321	11 879
1988	2 210	341	1 059	1 759	414	4 430	1 338	12 021
1989	2 281	341	1 088	1 840	425	4 809	1 399	12 354
1990	2 328	335	1 109	1 896	432	4 770	1 292	11 942
1991	2 395	336	1 136	1 973	443	5 341	1 431	12 613
1992	2 458	334	1 161	2 046	452	5 615	1 428	12 673
1993	2 529	333	1 190	2 130	463	6 131	1 508	13 087
1994	2 590	331	1 216	2 204	473	6 338	1 468	12 988
1995	2 666	331	1 246	2 295	484	7 103	1 607	13 653
1996	2 731	328	1 272	2 374	494	7 326	1 550	13 497
1997	2 799	327	1 300	2 458	504	7 921	1 612	13 834
1998	2 851	324	1 321	2 526	512	8 040	1 535	13 579
1999	2 930	325	1 352	2 623	524	9 240	1 749	14 551
2000	3 007	324	1 384	2 722	535	9 939	1 779	14 774

OPTIMISTIC SCENARIO

Table III.4. Canadian Consumption Forecasts of Forest Products 1984-2000

Year	Paperboard	Wrapping Paper	Newsprint	Culture paper	Building boards	Panels	Lumber	
							Hardwood	Softwood
	('000 tonnes)					('000 m^3)		
1984	1 993	347	965	1 511	378	3 783	1 370	13 489
1985	2 058	349	993	1 584	389	3 821	1 277	11 600
1986	2 097	343	1 012	1 634	396	3 753	1 171	11 166
1987	2 176	346	1 045	1 723	409	4 439	1 406	12 274
1988	2 270	344	1 084	1 828	423	5 000	1 523	12 853
1989	2 360	342	1 120	1 929	437	5 444	1 555	13 083
1990	2 420	335	1 145	1 998	446	5 363	1 392	12 476
1991	2 488	334	1 171	2 075	456	5 839	1 469	12 873
1992	2 552	332	1 197	2 149	466	6 156	1 474	12 967
1993	2 626	331	1 227	2 237	477	6 790	1 573	13 466
1994	2 718	332	1 263	2 347	490	7 748	1 737	14 237
1995	2 755	325	1 278	2 392	496	7 032	1 395	12 859
1996	2 828	326	1 307	2 481	507	8 236	1 657	14 055
1997	2 912	326	1 340	2 583	519	9 203	1 783	14 663
1998	2 996	325	1 373	2 689	531	9 959	1 817	14 907
1999	3 075	324	1 404	2 789	543	10 724	1 842	15 111
2000	3 150	322	1 434	2 885	554	11 342	1 827	15 151

PESSIMISTIC SCENARIO

Table III.5. Canadian Consumption Forecasts of Forest Products 1984-2000

Year	Paperboard	Wrapping Paper	Newsprint	Culture paper	Building boards	Panels	Lumber	
							Hardwood	Softwood
			('000 tonnes)				('000 m^3)	
1984	1 992	347	964	1 510	378	3 768	1 363	13 454
1985	2 058	348	993	1 584	389	3 832	1 283	11 627
1986	2 072	339	1 000	1 602	392	3 450	1 049	10 571
1987	2 125	340	1 023	1 662	400	3 985	1 251	11 555
1988	2 178	339	1 046	1 725	409	4 177	1 263	11 662
1989	2 235	340	1 071	1 793	418	4 466	1 309	11 920
1990	2 277	337	1 090	1 844	425	4 479	1 243	11 670
1991	2 344	338	1 118	1 922	436	5 066	1 403	12 439
1992	2 418	337	1 147	2 006	447	5 532	1 475	12 823
1993	2 495	336	1 179	2 097	459	6 034	1 538	13 173
1994	2 544	330	1 198	2 153	466	5 897	1 380	12 559
1995	2 583	327	1 215	2 203	472	5 986	1 342	12 433
1996	2 639	329	1 239	2 275	481	6 596	1 467	13 040
1997	2 694	327	1 262	2 344	490	6 941	1 483	13 171
1998	2 744	326	1 284	2 409	498	7 181	1 467	13 162
1999	2 802	325	1 308	2 483	507	7 772	1 552	13 589
2000	2 870	325	1 336	2 570	517	8 945	1 645	14 059